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No. 216

CLASSIFICATION OF
GENEVIEVIAN AND CHESTERIAN
(LATE MISSISSIPPIAN)
ROCKS OF ILLINOIS

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CLASSIFICATION OF GENEVIEVIAN AND CHESTERIAN (LATE MISSISSIPPIAN) ROCKS OF ILLINOIS

D. H. Swann



Illinois State Geological Survey Report of Investigations 216

Urbana, Illinois

1963

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PLATE	
1. Chesterian and Genevievian rock columns	<i>in pocket</i>

CLASSIFICATION OF GENEVIEVIAN AND CHESTERIAN (LATE MISSISSIPPIAN) ROCKS OF ILLINOIS

D. H. Swann

ABSTRACT

The Mississippian System is divided into the Kinderhookian, Valmeyeran, and Chesterian Series. Classification of late Valmeyeran and Chesterian rocks is herein considered in light of improved correlations and the adoption of the principle of multiple classification. Youngest Valmeyeran strata constitute the Genevievian Stage. The Chesterian is divided into the Gasperian (oldest), Hombergian, and Elviran Stages.

About a fourth of the Genevievian and Chesterian rocks of the Illinois Basin are locally derived carbonate, a fourth are sandstone, and half are shale. The terrigenous clastics were not derived from the flanking positive elements of the Ozark and Cincinnati Arches but were carried from source areas far to the northeast by a major river system which is herein named the Michigan River. Factors determining the succession and placement of the rock bodies include cyclic fluctuation of the shoreline from northeast (landward) to southwest (seaward) through a range of several hundred miles, lateral shifts in the lower course of the Michigan River from southeast to northwest through a range of about 200 miles, and a dominantly northwestward marine current.

Twenty-two formations, alternately carbonate-dominated and clastic-dominated, are recognized. The Ste. Genevieve Limestone, all or most of the Aux Vases Sandstone, and part of the Renault Limestone are of Genevievian age. Possibly part of the Aux Vases, most of the Renault, and all of the Yankeetown Sandstone, the Downeys Bluff Limestone, the Bethel Sandstone, the Ridenhower Formation, the Cypress Sandstone, and the Beech Creek Limestone are of Gasperian age. The Fraileys Shale, the Haney Limestone, the Hardinsburg Sandstone, and the Glen Dean Limestone are of Hombergian age. The Tar Springs Sandstone, the Vienna Limestone, the Waltersburg Formation, the Menard Limestone, the Palestine Sandstone, the Clore Formation, the Degonia Sandstone, the Kinkaid Limestone (restricted), and the Grove Church Shale (new) are of Elviran age.

In eastern Illinois the Ste. Genevieve Limestone comprises the Fredonia Limestone Member (restricted), the Spar Mountain Sandstone Member, the Karnak Limestone Member (new), and the Joppa Member (new); the Aux Vases Sandstone includes only the Rosiclare Sandstone Member; the Renault Limestone includes the Levias Limestone Member of Genevievian age and the Shetlerville Limestone Member (restricted) of Gasperian age. The Lost River Chert Bed is recognized in the lower part of the Fredonia Member, the Bryantsville Breccia Bed at the top of the Levias Member, and the Popcorn Sandstone Bed (new) at the base of the Shetlerville Member.

In central Illinois the Joppa as well as the Rosiclare is included in the Aux Vases, and in parts of western Illinois the Karnak and Levias Members cannot be identified and the Aux Vases probably includes the Spar Mountain Member and perhaps the Popcorn Bed. The Aux Vases is recognized throughout Illinois and eastward a short distance into Indiana and Kentucky. The Renault cannot be recognized as a formation east of the eastern edge of the Aux Vases, and its members are reassigned, the Levias being incorporated into the Ste. Genevieve and the Shetlerville combining with younger units to form the Paoli Limestone (Shetlerville-Downeys Bluff) or the Gasper Limestone (Shetlerville-Beech Creek). The Beaver Bend Limestone, the Sample Sandstone, and the Reelsville Limestone have formational rank in Indiana and Kentucky but are considered members

SER. STG.	COLUMNAR SECTION	MEMBER	FORMATION	GROUP W.	MEGA-E. GROUP
C H E S T E R I A N	E L V I R A N •		GROVE CHURCH *		
		Goreville*	KINKAID †		
		Cave Hill*			
		Negli Creek			
			DEGONIA		
		Ford Station*	CLORE		
		Tygett*			
		Cora*			
			PALESTINE		
		Allard*	MENARD		
		Scottsburg*			
		Walche*			
			WALTERSBURG		
			VIENNA		
			TAR SPRINGS		
	HOMBERGIAN •		GLEN DEAN	O K A W	GOLCONDA
			HARDINSBURG		
			HANEY		
			FRAILEYS		
		Big Clifty			
	GASPERIAN •		BEECH CREEK	P A I N T C R E E K	W E S T B A D E N
			CYPRESS		
		Reelsville	RIDENHOWER		
		Sample			
		Beaver Bend	BETHEL		
			DOWNEYS BLUFF		
			YANKEETOWN		
		Shetlerville†	RENAULT		
V A L M E Y E R A N	G E N E V I E V I A N •	Levias	S T E . G E N E V I E V E	C E D A R * B L U F F	M A M M O T H C A V E
		Rosiclare			
		Joppa*			
		Karnak*			
		Spar Mt.			
		Fredonia†			

* New Name

• New in this Form

† Restricted

of the Ridenhower in Illinois. The Big Clifty Sandstone is recognized as a formation equivalent to the Fraileys Shale in Indiana and Kentucky, but is a member within the Fraileys in Illinois. The Walche, Scottsburg, and Allard Limestone Members (all new) are recognized in the Menard but intervening and overlying shale units are not named. The Clore Formation comprises the Cora Member, the Tygett Sandstone Member and the Ford Station Member (all new). The Kinkaid Limestone comprises the Negli Creek Limestone Member, the Cave Hill Shale Member (new), and the Goreville Limestone Member (new).

The Paint Creek Group (Downeys Bluff–Ridenhower) and the Okaw Limestone Group (Beech Creek–Glen Dean) are recognized in western Illinois. The Cedar Bluff Limestone Group (new) (Renault–Downeys Bluff), the West Baden Group (Bethel–Cypress), and the Golconda Group (Beech Creek–Haney) are recognized in eastern Illinois. The boundary between the Mammoth Cave Limestone Megagroup and the Pope Megagroup rises in a series of offsets or steps from the base of the Genevievian at the northwest edge of the Illinois Basin to the top of the Gasperian at the southeast.

INTRODUCTION

The main succession of Mississippian limestones in the Illinois region is separated from the clastic-dominated Pennsylvanian rocks by a transitional sequence of alternating sandy and limy strata. Non-geographic names were applied to the transitional unit until about a century ago, when the names Kaskaskia (Hall, 1857) and Chester (Worthen, 1860) were introduced for the entire succession. The most prominent individual units were named at about this time or during the next half century. In 1904 and 1905 Ulrich made the first systematic subdivision of the succession, and a few years later Stuart Weller (1913) established a complete column of formational units. In the next decade classification of these rocks was completed not only in Illinois and Missouri (S. Weller, 1920a, 1920b) but also in Kentucky (Butts, 1917; S. Weller, 1921) and Indiana (Malott, 1919, 1925; Cumings, 1922). Minor corrections and changes of the succeeding 15 years were summarized by J. M. Weller and Sutton (1940) and incorporated in the Geological Society of America correlation chart (J. M. Weller et al., 1948).

The present paper summarizes the changes of the past two decades. It pre-

sents a classification of late Mississippian rocks of Illinois (fig. 1) and applies this classification to outcrops and the subsurface (pl. 1). It shows the relation of this classification to earlier ones and to the slightly differing classifications of neighboring states (figs. 16 to 23).

Innovations in the present classification result largely from acceptance of multiple classification and from recent stratigraphic information obtained by drilling for oil.

Multiple classification demands a clear separation of stratigraphic units based on time of origin from those based on lithologic criteria. Systems, series, and stages are the units of time-stratigraphic classification, whereas megagroups, groups, formations, members, and beds are used in rock-stratigraphic classification. Four units that formerly were considered formations or groups were commonly used as though they were time-stratigraphic units. These are now recognized as stages and carry adjectival names (Genevievian, Gasperian, Hombergian, and Elviran).

Study of the many excellent records of closely spaced drill holes now available shows that some correlations held at the time of Weller and Sutton's comprehensive treatment in 1940 can no longer be accepted. Revision of these correlations demands revision of names and classification.

FIG. 1—Classification of the late Mississippian rocks of Illinois. Three thin units are named in addition to those labelled on the chart—the Lost River Chert Bed in the lower part of the Fredonia Member, the Bryantville Breccia Bed at the top of the Levias Member, and the Popcorn Sandstone Bed (new) at the base of the Shetlerville Member.

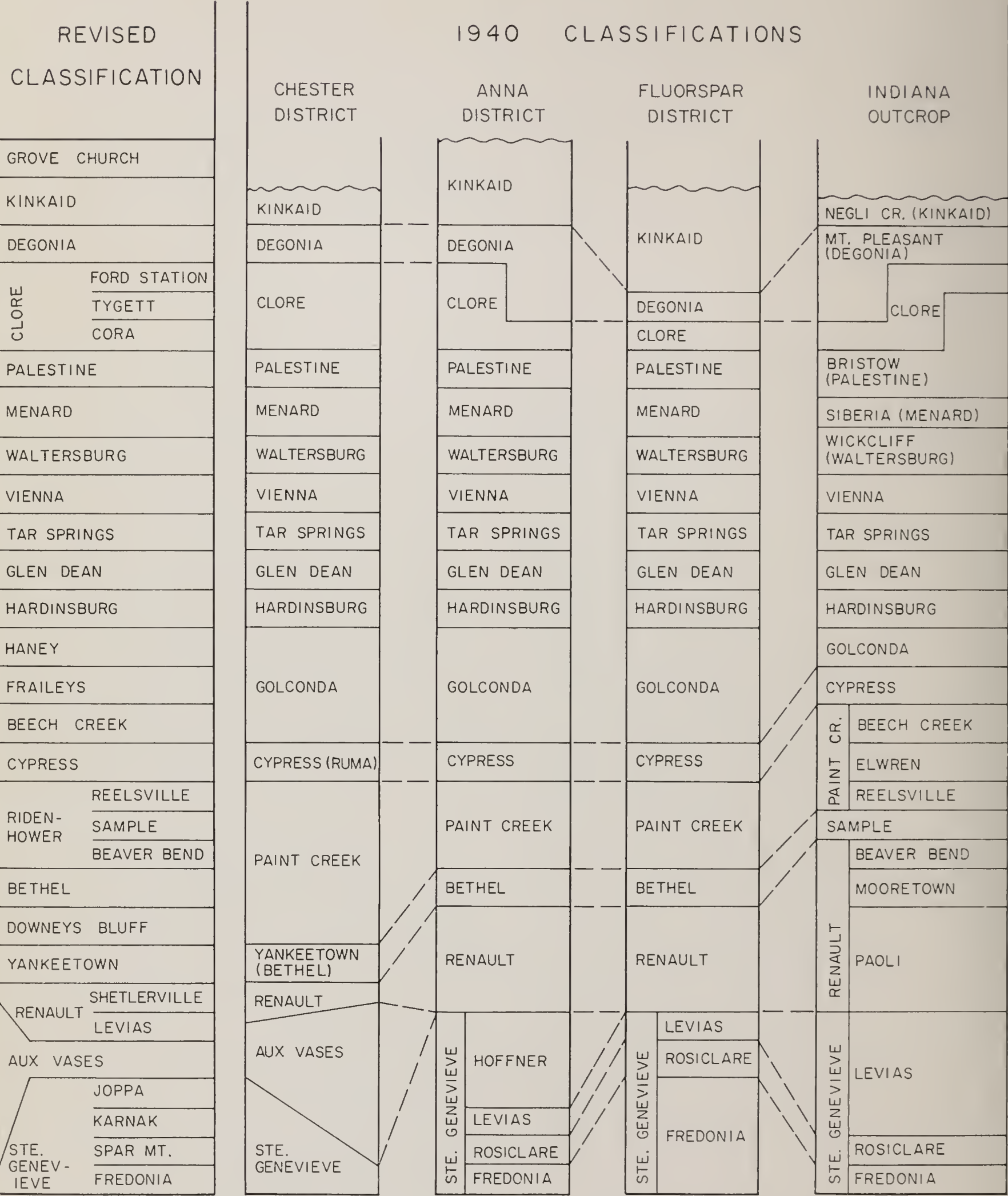


FIG. 2—Changes in Genevievian and Chesterian correlation since 1940. The 1940 correlations are indicated by dashed lines. The revised correlation is shown by conventional horizontal placement. The 1940 columns are from Weller and Sutton (1940) with minor modifications from J. M. Weller (1939), Stouder (1938), and Malott (1946b).

The need for revision was first indicated by subsurface studies (Dana and Scobey, 1941; Swann and Atherton, 1948). The subsurface results were verified by further work in the outcrop areas.

Figure 2 indicates several of the major changes in correlation that have been made since 1940. The sandstone formerly called Rosiclare in outcrops in Indiana and near Anna, Illinois, and in oil fields in the northern and western parts of the Illinois Basin actually correlates with the Spar Mountain Sandstone Member that lies about 60 feet beneath the type Rosiclare of the fluorspar district. The type Rosiclare of the fluorspar district is now considered equivalent to part of the Hoffner Member of the Anna district and to part of the Aux Vases Sandstone of the Chester district and the subsurface. The Yankeetown Sandstone of the Chester district and the Bethel Sandstone of the fluorspar district lie, respectively, beneath and above the Downeys Bluff Limestone, and are not correlative. The Bethel of the fluorspar district and the Sample Sandstone of Indiana and central Kentucky lie beneath and above the Beaver Bend Limestone rather than correlating with each other. The type Cypress Sandstone of Illinois and the Big Clifty ("Indiana Cypress") of Kentucky and Indiana lie, respectively, beneath and above the Beech Creek Limestone. The sandstone in the fluorspar district formerly called De-gonia lies beneath the upper limestone member of the Clore Formation.

Few changes in names have been made other than those necessitated by the revised correlations. Members recognized informally in the Menard and Kinkaid Formations are formally named in this report. The youngest Chesterian beds, those above the Goreville (upper limestone) Member of the Kinkaid Formation, are removed from that formation to form a new unit, the Grove Church Formation.

Type localities for formally named units in the Chesterian and Genevievian of the Illinois Basin are shown in figure 3. These indicate the general position of the outcrop belt around the southern rim of the basin.

The northern limit of these rocks is buried beneath the Pennsylvanian.

Acknowledgments

The writer is indebted to the many geologists with whom he has discussed Chesterian stratigraphy and who have shown him outcrops, cross sections, and maps; to present and former colleagues at the Illinois State Geological Survey; to the staffs of neighboring geological surveys and schools; and to many in the oil, quarrying, and fluorspar industries.

Elwood Atherton, of the Survey staff, has been closely associated with this work and assisted in preparation of most of the illustrations. H. B. Willman, also of the Survey, has directed the study. In addition to Drs. Willman and Atherton, Charles Col-linson, Charles A. Ross, and James W. Baxter of the Survey staff, E. G. Sable of the United States Geological Survey, and Eugene Frund of the Humble Oil Company have read all or much of the manuscript. L. L. Whiting and J. E. Lamar contributed helpful information and suggestions. There have been many field and office conferences with the staffs of the state surveys with whom we share the Illinois Basin. Those participating from Indiana have included John B. Patton, Thomas A. Dawson, Ned M. Smith, Arthur P. Pinsak, Henry H. Gray, and Dan M. Sullivan. Kentucky has been represented by Arthur C. McFarlan, Wallace W. Hagen, Edmund Nosow, Frank H. Walker, and E. R. Branson. Missouri participants have included Thomas R. Beveridge, Alfred C. Spreng, and James A. Martin.

Mrs. L. L. Whiting, Mrs. W. M. Swann, and Mrs. D. H. Swann have read many versions of the manuscript to me.

REGIONAL SETTING

During the Mississippian Period, the Illinois Basin was a slowly subsiding region with a vague north-south structural axis. It was flanked by structurally neutral regions to the east and west, corresponding to the present Cincinnati and Ozark Arches. These

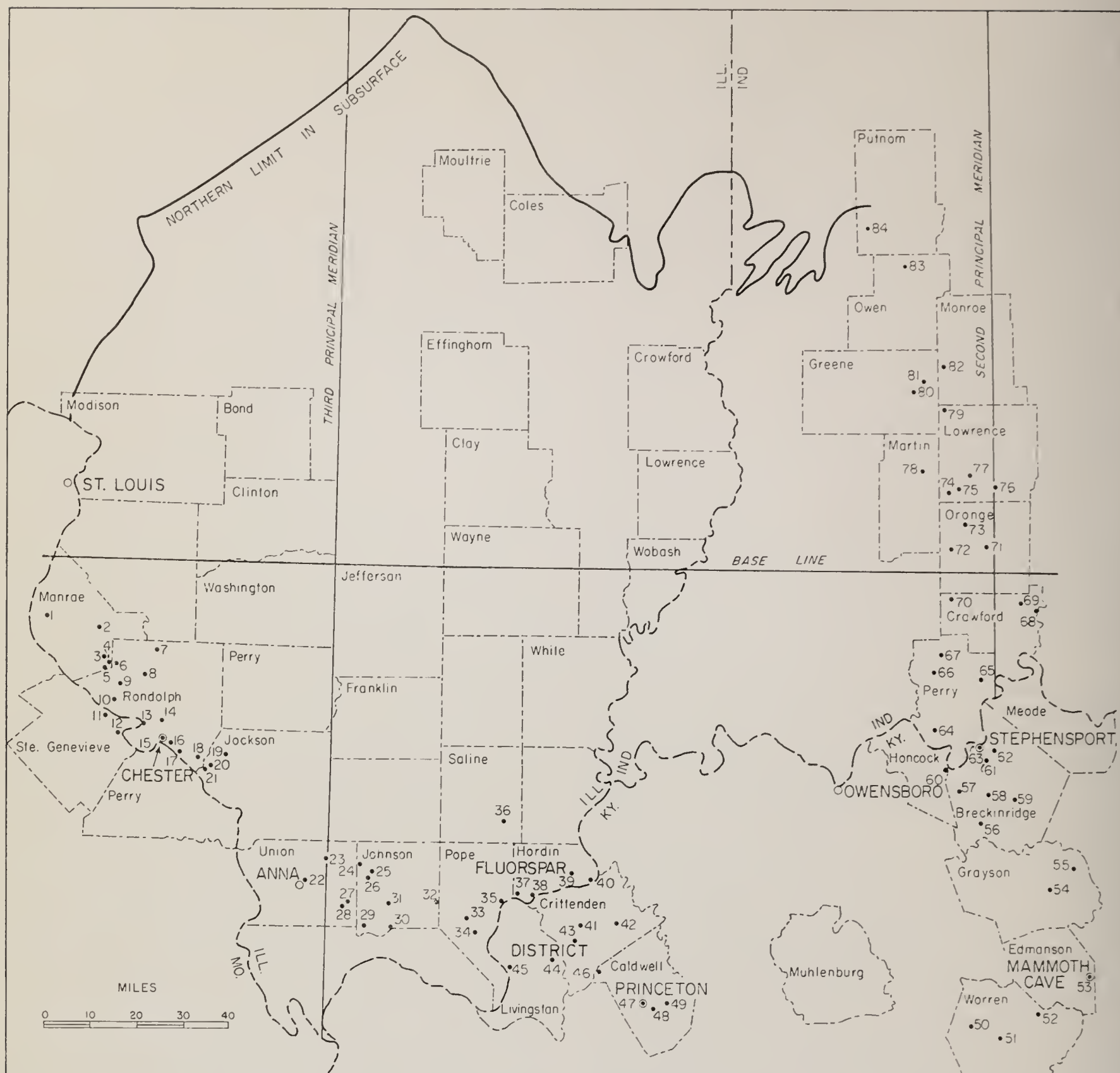


FIG. 3—Type localities and extent of Genevievian and Chesterian rocks in the Illinois Basin. Chester district, Anna district, fluorspar district, Princeton district, Mammoth Cave district, Stephensport district, and Owensboro district are indefinite broad areas.

neighboring elements contributed insignificant amounts of sediment to the basin. Instead, the basin was filled by locally precipitated carbonate and by mud and sand eroded from highland areas far to the northeast in the eastern part of the Canadian Shield and perhaps the northeastward extension of the Appalachians. This sediment was brought to the Illinois region by a major river system, which it will be convenient to call the Michigan River (fig. 4) because it crossed the present state of Michigan from north to south or northeast

to southwest. The Michigan River is analogous to the Ontario River (Pepper et al., 1954), which contemporaneously carried material to the northern part of the Appalachian Basin.

The Michigan River delivered much sediment to the Illinois region during early Mississippian time. However, an advance of the sea midway in the Mississippian Period prevented sand and mud from reaching the area during deposition of the St. Louis Limestone. Genevievian time began with the lowering of sea level and the al-

KEY TO LOCALITIES ON FIGURE 3

No.	Name	No.	Name	No.	Name
1	Valmeyeran	30	Ridenhower	58	Hardinsburg
2	New Design	31	Vienna	59	Garfield
3	Renault	32	Allard	60	Buffalo Wallow
4	Yankeetown	33	Waltersburg	61	Rock House
5	Paint Creek	34	Hombergian		Shot Pouch
6	Ruma	35	Golconda	62	Sample
7	Baldwin		Lusk	63	Clover Creek
8	Plum Creek	36	Cave Hill		Stephensport
9	Marigold	37	Shetlerville	64	Negli Creek
10	Brewerville	38	Downeys Bluff	65	Mt. Pleasant
11	Genevievian		Rosiclare	66	Bristow
	Ste. Genevieve	39	Spar Mountain	67	Siberia
12	Aux Vases	40	Fraileys	68	Blue River
13	Kaskaskia		Haney	69	Brandy Run
	Chartresan	41	Bethel	70	Wickcliff
14	Palestine	42	Tribune	71	Paoli
15	Chesterian	43	Levias	72	French Lick
	Menard	44	Lockhart		West Baden
16	Clore	45	Birdsville	73	Lost River
17	Ford Station	46	Fredonia	74	Beaver Bend
18	Rockwood	47	Princeton		Huron
19	Kinkaid	48	Cedar Bluff	75	Mooretown
20	Degonia		Ohara	76	Mitchell
21	Cora	49	Scottsburg	77	Bryantsville
22	Swan Creek		Walche	78	Indian Springs
23	Tygett	50	Gasperian	79	Popcorn
24	Grove Church	51	Bowling Green	80	Beech Creek
25	Goreville	52	Girkin	81	Solsberry
26	Elviran	53	Mammoth Cave	82	Elwren
27	Cypress	54	Leitchfield	83	Cataract Falls
28	Hoffner	55	Big Clifty	84	Reelsville
29	Joppa	56	Glen Dean		
	Karnak	57	Tar Springs		

ternating deposition of shallow-water carbonate and clastic units in a pattern that persisted throughout the rest of the Mississippian. About a fourth of the fill of the basin during the late Mississippian was carbonate, another fourth was sand, and the remainder was mud carried down by the Michigan River.

Thickness, facies, and crossbedding (Swann and Bell, 1958; Potter et al., 1958) indicate the existence of a regional slope to the southwest, perpendicular to the pre-

vailing north 65° west trend of the shorelines. The Illinois Basin, although developing structurally during this time, was not an embayment of the interior sea. Indeed, the mouth of the Michigan River generally extended out into the sea as a bird-foot delta, and the shoreline across the basin area may have been convex more often than concave.

Figure 5 shows the major fluctuations in the position of the shore line and of the mouth of the Michigan River as interpreted

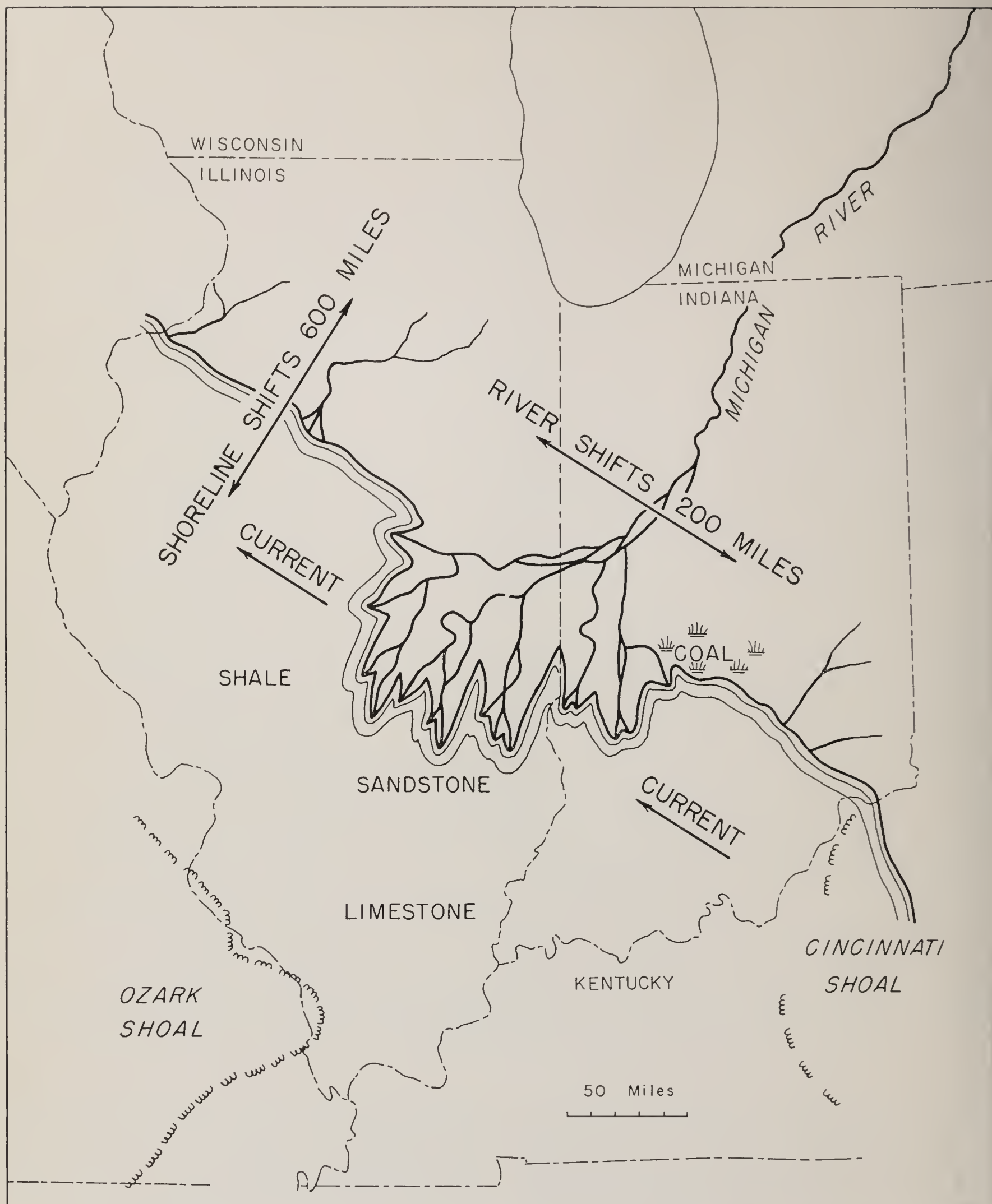


FIG. 4—Paleogeography at an intermediate stage during Chesterian sedimentation.

from the record of the sediments. The shoreline was not static. Its position oscillated through a range of perhaps 600 to 1000 or more miles. At times it was so far south that land conditions existed through-

out the present area of the Illinois Basin. At other times it was so far north that there is no suggestion of near-shore environment in the sediments still preserved. This migration of the shoreline and of the accom-

panying sedimentation belts determined the composition and position of Genevievian and Chesterian rock bodies.

Lateral shifts in the course of the Michigan River also influenced the placement of the rock bodies. At times the river brought its load of sediment to the eastern edge of the basin, at times to the center, and at times to the western edge. This lateral shifting occurred within a range of about 200 miles. The Cincinnati and Ozark areas did not themselves provide sediments, but, rather, the Michigan River tended to avoid those relatively positive areas in favor of the down-warped basin axis.

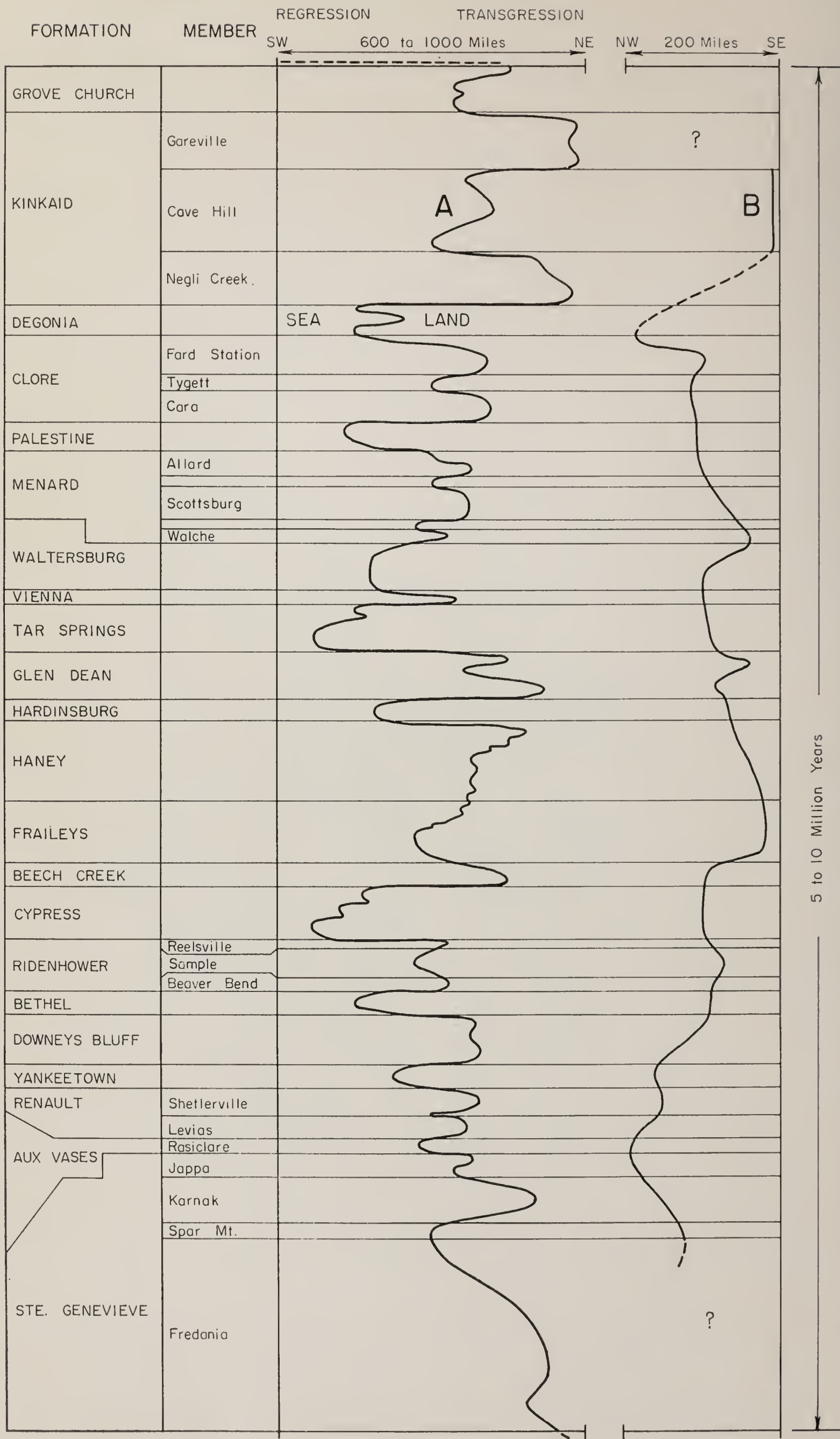
Sedimentation belts during this time were not symmetrical with respect to the mouth of the Michigan River. They were distorted by the position of the river relative to the Ozark and Cincinnati shoal areas, but of greater importance was sea current or drift to the northwest. This carried off most of the mud contributed by the river, narrowing the shale belt east of the river mouth and broadening it west of the mouth. Facies and isopach maps of individual units show several times as much shale west of the locus of sand deposition as east of it. The facies maps of the entire Chesterian (Swann and Bell, 1958) show maximum sandstone deposition in a northeast-southwest belt that bisects the basin. The total thickness of limestone is greatest along the southern border of the basin and is relatively constant along that entire border. The proportion of limestone, however, is much higher at the eastern end than along the rest of the southern border, because little mud was carried southeastward against the prevailing sea current. Instead, the mud was carried to the northwest and the highest proportion of shale is found in the northwestern part of the basin.

Genevievian and Chesterian seas generally extended from the Illinois Basin eastward across the Cincinnati Shoal area and the Appalachian Basin. Little terrigenous sediment reached the Cincinnati Shoal area from either the west or the east, and the section consists of thin limestone units representing all or most of the major cycles.

The proportion of inorganically precipitated limestone is relatively high and the waters over the shoal area were commonly hypersaline (McFarlan and Walker, 1956; Peterson, 1962). Erosion of the shoal area at times is indicated by the presence of conodonts eroded from the St. Louis Limestone and redeposited in the lower part of the Gasper Limestone at the southeast corner of the Illinois Basin (Rexroad and Liebe, 1962).

The shoal area included regions somewhat east of the present Cincinnati axis and extended from Ohio, and probably southeastern Indiana, through central and east-central Kentucky and Tennessee into Alabama. Sediments of the Black Warrior Basin are similar to those of the Illinois Basin and were continuous with them before separation by post-Pennsylvanian erosion over the Pascola Arch.

The Appalachian Basin was filled in a similar manner, but clastics were brought to the basin in significant amounts by several streams entering along the southeast side of the basin as well as by the Ontario River at the north. Pepper et al. (1954) suggested that in early Mississippian time the river system here named the Michigan River was an extension of their Ontario River, which was diverted for a short time from the Appalachian to the Michigan Basin. They compared it to the modern Hwang Ho (Yellow) of China which empties into the Yellow Sea alternately north and south of the Shantung Mountains. The suggestion is plausible if only the Bedford and Berea sediments of Michigan and Ohio are considered, but not when the study is extended to a larger area over a longer segment of time. About 40 diversions of sediments to areas 400 to 600 miles apart, first to the east and then the west of the Cincinnati Shoal region, would be required for the late Mississippian. The time scale provided by biostratigraphy is too coarse to indicate whether the pulses of clastic deposition in the Appalachian and Illinois Basins were in phase or alternate. However, the mechanism for repeated stream diversion operates only in an aggrading region, and the Paleozoic history



of the Cincinnati-Findlay-Algonquin-Ontario axis as a positive feature precludes there being an area of continued deposition along it many hundred miles upstream from the river mouths.

Toward the west, the seaway was commonly continuous between the Illinois Basin and central Iowa, although only the record of Genevievian and earliest Chesterian is still preserved. The seas generally extended from the Illinois and Black Warrior regions into the Arkansas Valley region, and the presence of Chesterian outliers high in the Ozarks indicates that at times the Ozark area was covered. Although the sea was continuous into the Ouachita region, detailed correlation of the Illinois sediments with the geosynclinal deposits of this area is difficult.

TIME STRATIGRAPHY

The Illinois State Geological Survey divides the Mississippian System into the Kinderhookian (oldest), Valmeyeran, and Chesterian Series. This report concerns the Chesterian and the upper part of the Valmeyeran in the Mississippi Valley region, which provides the North American standard for this part of the geologic column.

Revising stratigraphic names in an area that includes the types of widely used time units poses problems that do not arise elsewhere. Most time-stratigraphic units were originally rock-stratigraphic. After a name is used elsewhere in a purely time sense, it may retain its rock meaning in the type region. Difficulties arise because the lithologic discontinuities that bound rock-stratigraphic units do not necessarily correspond to the time planes that bound time-stratigraphic units. In addition, the criteria that are most helpful in tracing a time-stratigraphic boundary may not be available in the type region. Thus, a widely used operational definition of the time-bounded unit may be poorly adjusted to the theoretical definition based on its type section.

It seems futile to try to eliminate a widely used term such as Chesterian because its time-stratigraphic boundaries do not correspond exactly to the local lithologic boundaries. It may be wiser to modify the formal definition of the time-stratigraphic unit to meet the working definition, and perhaps to invent a new name for the local rock-stratigraphic unit.

VALMEYERAN-CHESTERIAN BOUNDARY

J. M. Weller and Sutton (*in* Moore, 1933) erected the Valmeyeran Series to include the rocks that had been placed in the Osagian and Meramecan* Series, or had been considered equivalent to the Osage and Meramec Groups. This unit was accepted by the Illinois Geological Survey in 1956 (Workman and Gillette). It is doubtful that either of the boundaries generally used to separate the Osagian and the Meramecan (above or below the Warsaw Shale) can be widely traced. The beds immediately beneath the Chesterian are here designated Valmeyeran, although they were classified as Meramec, Iowa, Middle Mississippian, Lower Mississippian, or some variant of these in most of the literature cited.

Ste. Genevieve Assigned to Valmeyeran

Whether the Ste. Genevieve Limestone should be placed in the Valmeyeran or the Chesterian Series was the subject of a heated debate that lasted over two decades and was not resolved until 1938 (Wilmarth) when the Ste. Genevieve was placed in the Valmeyeran. Many of the arguments presented on both sides are still valid, and it is doubtful that a unanimous decision could be reached in any revival of the controversy. It is clearer today that the Ste. Genevieve is very closely allied to the Chesterian in its mode of origin and that there was no important "time break" following Ste. Genevieve deposition. However, there also is more support today for the

FIG. 5—(A) Changes in position of the shoreline and (B) lateral shift in the position of the Michigan River during Genevievian and Chesterian time.

*The form Meramecan parallels the accepted terms Aztecan and Toltecan and avoids confusion in pronouncing Meramecian.

view that the geologic time units are somewhat arbitrary divisions of continuous time rather than natural episodes. Biostratigraphic zonation allows more precise determination of an isochronous surface at the top of the Ste. Genevieve than at its base, at least in the central and eastern United States. The Ste. Genevieve, therefore, is retained in the Valmeyeran.

Aux Vases Assigned to Valmeyeran

The Aux Vases Sandstone, traditionally basal Chesterian, is here placed in the Valmeyeran. The evidence for correlating the Aux Vases with fossiliferous limestone placed in the Ste. Genevieve follows in detail.

Two types of criteria, paleontologic and lithologic, were used to separate the Ste. Genevieve from the formations formerly considered Chesterian. The differentiation was lithologic in the subsurface of most of the Illinois Basin. It was paleontologic in all outcrop areas except the Chester district (Ste. Genevieve and Perry Counties, Missouri, and Monroe and Randolph Counties, Illinois). The Chester district includes the type localities of Valmeyeran, Ste. Genevieve, Aux Vases, and Renault. In that area the beds assigned to the Ste. Genevieve are almost entirely limestone, typically oolitic and fossiliferous. Overlying these is a sequence of 40 to more than 100 feet of non-fossiliferous or poorly fossiliferous clastic rock belonging to the Aux Vases Sandstone and the Renault Formation, both of which have in the past been assigned to the Chesterian.

In outcrop areas in the southeastern part of Illinois, in Kentucky, Indiana, Tennessee, Alabama, Georgia, Virginia, and West Virginia, light colored fossiliferous crinoid-bearing limestones of the Ste. Genevieve are overlain by similar limestones placed in various Chesterian formations. Ste. Genevieve beds are characterized by, among other fossils, the distinctive sculptured heads and particularly the spiny elliptical stem segments of the crinoid *Platycrinites penicillus*. The overlying Chesterian formations are characterized by the presence of

species of the crinoid *Talarocrinus* that have smooth, somewhat inflated plates. (The tiny, stemless *T. simplex* of the Salem Limestone cannot be confused with these later species and probably is not closely related to them.) This paleontologic differentiation has served very well. In literally hundreds of localities in scores of counties in eight states, *Talarocrinus* has been found a few feet or even a few inches above the highest beds containing *P. penicillus*. Where reworking can be excluded the two forms do not overlap.

Small, smooth, elliptical stem segments are rarely found in *Talarocrinus*-bearing beds. In the northeastern corner of the Cub Run Quadrangle, Hart County, in the southern part of the Stephensonport district, Kentucky, fragmentary *Platycrinites* stem segments, some with spines and some smooth, have been found with *Talarocrinus patei*, but may be reworked (E. G. Sable, personal communication, 1962).

The fact that both forms are found in the same type of rock suggests that the *Platycrinites-Talarocrinus* boundary is not controlled by facies but that it approaches a true time plane. Although the lithologic criteria used to trace this boundary are rather subtle, the paleontologic boundary corresponds to bedding planes that can be traced on a physical basis for scores of miles.

Outcrop Relations of the Ste. Genevieve and Aux Vases Formations

As the Ste. Genevieve Limestone is traced westward from Kentucky across southern Illinois, clastic beds increasingly replace the limestone in the upper half of the formation. Thin tongues of calcareous siltstone and shale extend a few miles into Kentucky. In Hardin County, southeastern Illinois, clastics form about a tenth of the upper 100 feet of the Ste. Genevieve, the proportion increasing westward until in Union County, southwestern Illinois, limestones equivalent to the lower part of the Ste. Genevieve Formation farther east are overlain by 50 to 130 feet of rocks that are nearly all clastic. Because they contain oc-

casional lenses of limestone and hematitic oolite with *Platycrinites penicillus*, these beds also have been placed in the Ste. Genevieve despite their clastic nature. They are overlain by a series of limestones and shales that contain *Talarocrinus* and that are therefore assigned to the Chesterian. Thus in Union County the boundary traditionally has been determined paleontologically, even though a clastic unit beneath the boundary is overlain by a dominantly limestone unit above.

The limestone sequence in the lower part of the Ste. Genevieve in Union County, Illinois, is duplicated across the river in southeastern Perry County, Missouri. The limestone and shale sequence at the base of the Chesterian in Union County also is duplicated there. The two carbonate-dominated sequences are separated by 55 to 105 feet of clastic rocks in both counties (J. M. Weller and Sutton, 1940, p. 821). Although there are a few beds of slightly crinoidal sandstone in the clastic unit in Perry County, no identifiable fossils have been collected. However, the Perry County clastics are lithologically indistinguishable from those traditionally placed in the upper part of the Ste. Genevieve east of the Mississippi River. In Perry County the unit has been correctly correlated as the Aux Vases Sandstone, and it has therefore been classified as Chesterian, placing the Chesterian boundary at the base of the clastic section, 100 feet or so beneath the *Talarocrinus*-bearing limestones. East of the river, however, the base of the Chesterian has been picked paleontologically at the base of the *Talarocrinus*-bearing limestone, despite the fact that the beds underneath are clastic.

Both the Ste. Genevieve and the Aux Vases thin to the northwest along the Mississippi River from the southeast corner of Perry County. Although well samples show the Aux Vases contains some carbonate in the type region, very little is visible in the outcrops. Outcrops have been assigned to the Aux Vases where sandstones predominate and to an unfossiliferous lower part of the Renault where shale is dominant (Weller and Weller, 1939, p. 10).

Ste. Genevieve Fossils in the Aux Vases

Fossiliferous outcrops of the Aux Vases are rare and the stratigraphic relation of some fossiliferous outcrops possibly at this level is uncertain. One important fossiliferous Aux Vases outcrop was pointed out by Ulrich (1922) but ignored by later writers. It is in the type section of the Aux Vases in the bluffs at the mouth of the Aux Vases River in Ste. Genevieve County, Missouri. Seventeen feet of sandstone is exposed there in a cut on the west side of Missouri Highway 25 as it climbs the bluff south of the bridge over the Aux Vases River. The sandstone section, the top few inches of which are very calcareous and sparingly fossiliferous, is capped by 2 or 3 feet of plastic green and red clay that contains lenses of fossiliferous crinoidal limestone. The clay is covered by loess, and is usually very poorly exposed. In wet weather, the clay flows out into the highway carrying loess with it, so that the loess bank has receded several feet since the highway was built. The clay zone can be traced westward as a bench in the hill slope for about 1000 feet up the valley wall of the Aux Vases River, with occasional outcrops of Aux Vases Sandstone both above and below it. It pinches out just before reaching an uninterrupted 40-foot exposure of sandstone resting on Ste. Genevieve Limestone in the gully west and hillslope east of a secondary road.

The sandstone beneath the clay bed is also exposed on the east side of Highway 25 beneath the road level. The clay can be seen, 5 to 6 feet thick but without limestone lenses, on the east side of the highway about 500 feet south of the exposure on the west side. Four hundred feet farther south in the Mississippi River bluffs the clay zone is well exposed just above a farm lane beside the Missouri Pacific Railroad tracks. Here its base is a lens of crinoidal limestone 1 to 2½ feet thick that lies on sandstone with a marked disconformity. Stem segments of *Platycrinites penicillus* are prominently displayed on the upper surface of the limestone lens. Twenty-eight feet of

sandstone and shale in the upper part of the Aux Vases, well exposed at this point, separates this limestone lens from the lowest limestone bed in the Renault. *Talarocrinus* can be collected from that bed in the Renault several hundred feet farther south. The fauna of the limestone lens in the Aux Vases is listed by Ulrich (1922) and that of the Renault by S. Weller and St. Clair (1928).

Subsurface Relations of the Aux Vases

Subsurface evidence that the Aux Vases is contemporaneous with limestones placed in the Ste. Genevieve farther east is particularly convincing. Although outcrops of the Aux Vases in Illinois east of the type region have not been mentioned in the literature and outcrops in Kentucky or Indiana have not been correctly identified, the Aux Vases is recognized everywhere in the subsurface of Illinois and a short distance eastward into the subsurface of Indiana and Kentucky. The unit identified as Aux Vases in subsurface records in the basin is physically continuous with the Aux Vases of the type area. This is proved by a network of correlations involving literally tens of thousands of wells. Swann and Atherton (1948) showed that the subsurface Aux Vases underlies the *Platycrinites penicillus*-bearing Levias Limestone Member that heretofore has been placed at the top of the Ste. Genevieve in the fluorspar district of Illinois and Kentucky. The internal stratigraphy of the Aux Vases based on grain-size data confirms this correlation (Swann et al., 1959).

Summary

The physical criteria used in the type region until now place the Ste. Genevieve-Chesterian boundary lower than does the paleontologic criterion used in the outcrops farther east.

The physical criteria can be used only as far as the Aux Vases Sandstone can be traced—that is, only within the larger part of the Illinois Basin. Moreover, it is shown later that their use results in placing the boundary at three or more different stratigraphic levels within the basin. The pale-

ontologic criterion, on the other hand, provides a widely traceable and unique boundary. The Valmeyeran-Chesterian boundary is, therefore, placed at the *Platycrinites penicillus*-*Talarocrinus* boundary. The two series can be differentiated accurately in the crinoid-bearing facies, which is normal in the eastern United States. Like many time-stratigraphic boundaries, this one can be located precisely only where facies are suitable.

GENEVIEVIAN STAGE OF THE VALMEYERAN SERIES

The top of the Ste. Genevieve Limestone is here placed at the base of the Aux Vases Sandstone wherever the Aux Vases can be recognized. However, all or nearly all of the Aux Vases is older than the youngest occurrences of *Platycrinites penicillus* and thus the Aux Vases is transferred from the Chesterian to the Valmeyeran Series. The Levias Limestone Member, which overlies the Aux Vases and is thus by definition in the Renault Formation, also is of Valmeyeran age. The Ste. Genevieve is the youngest Valmeyeran formation only where the Aux Vases is not present.

It will be convenient to use a time-stratigraphic term for all the units deposited contemporaneously with the Ste. Genevieve Limestone where its top corresponds with the last occurrence of *Platycrinites penicillus*. The Genevievian Stage is here erected to fulfill this need. It is the only stage now recognized in the Valmeyeran, but it covers only the latest part of Valmeyeran time. It is named for the Ste. Genevieve Limestone and comprises all deposits contemporaneous with the entire range of the Ste. Genevieve.

In the Illinois Basin, the Genevievian Stage includes the Levias Limestone Member of the Renault Formation, all or most of the Aux Vases Sandstone, and some poorly fossiliferous shales and shaly sandstones in the western part of the basin that have generally been included in the lower part of the Renault. In most areas south and east of the Illinois Basin, the Genevievian consists of the Ste. Genevieve Limestone only.

The top boundary of the Genevievian is the Valmeyeran–Chesterian or *Platycrinites penicillus*–*Talarocrinus* boundary discussed above.

The base of the Genevievian is not as clearly defined as its top. Genevievian time began with the shallowing of the interior sea in most of the eastern states, when deposition of the dark lithographic limestones of the St. Louis Formation ceased and forms of *Lithostrotion* and *Lithostrotionella* with large corallites disappeared from this region. Further work may show that the boundary between two conodont zones, the *Apatognathus? geminus*–*Cavusgnathus* Assemblage Zone below and the *Gnathodus bilineatus*–*Cavusgnathus characta* Assemblage Zone above provides a more practical base for the Genevievian than does the disappearance of the corals or the change in sedimentation.

The Genevievian Stage is excluded from the Chesterian because for the last 25 to 40 years the Ste. Genevieve Limestone has been considered Valmeyeran, and because the upper boundary is readily traced in the crinoid-bearing facies of the eastern states. The boundary at the top of the Genevievian is difficult to use in other regions, and the eventual transfer of the Genevievian Stage to the Chesterian may occur if a lower boundary is chosen that can be traced more widely.

DIVISIONS OF THE CHESTERIAN SERIES

Three major divisions of the Chesterian Series are recognized. Though these have generally been called groups, their use has clearly been that of provincial stages. They have been used to designate rocks deposited during definite portions of Chesterian time rather than rocks associated because of similar lithologic characteristics. There has been quite widespread agreement as to which rocks should be assigned to each of the three divisions, most commonly known as the Lower, Middle, and Upper Chester. S. Weller (1920a) briefly used the term Okaw for the middle division and Cumings (1922) suggested the names West Baden and Stephensonport for the lower two

units, but the names have not been used further in this sense. J. M. Weller (1939), anticipating J. M. Weller and Sutton (1940), proposed the New Design, Homberg, and Elvira Groups for the three units. It is proposed here that the three units be recognized formally as stages and be named, in ascending order, the Gasperian, Hombergian, and Elviran Stages.

Although J. M. Weller and Sutton (1940) called the corresponding units groups rather than stages, their discussion is essentially time-stratigraphic rather than rock-stratigraphic. Their paper describes the distribution of the more significant fossils, and the ranges of several of these are shown graphically in J. M. Weller et al. (1948).

Gasperian Stage

The Gasperian Stage is here recognized to include Chesterian rocks equivalent to and older than the Beech Creek Limestone. It is named for the Gasper Limestone Formation, or Group, of Butts (1917). It comprises the strata deposited contemporaneously with the beds in Butts' type section along the Gasper River northwest of Bowling Green, Warren County, Kentucky. The stage corresponds exactly to the unit generally designated as Lower Chester in Indiana and Kentucky. It differs from the Lower Chester or New Design, as these terms have been used in southeastern Illinois, by including at the top the Cypress and Beech Creek (basal Golconda) Formations. It differs from the New Design Group, as used along the Mississippi River in the type area of that group, in that both the top and the bottom of the Gasperian are younger. It agrees reasonably well with the Lower Chester or Gasper Limestone as these terms have been used outside the Illinois Basin.

The lower boundary of the Gasperian is the same as the base of the Chesterian and has already been discussed.

The Cypress and Beech Creek Formations have historically been included in the Middle Chester in Illinois but in the Lower Chester in Kentucky and Indiana. The macrofauna of the Beech Creek in Indiana

and Kentucky has been accepted as typical early Chesterian for nearly 50 years. It was recognized that the fauna of the Beech Creek (the basal Okaw or basal Golconda) in Illinois, which had been assigned to the Middle Chester, differed from the typical middle Chesterian faunas of the other units placed in the Golconda in western Illinois. Some authors (Ulrich, 1917; Malott, 1952) suggested that the basal Okaw (Beech Creek) should be united with the Paint Creek because of the presence or abundance of such typically early Chesterian brachiopods as *Inflatia inflata* = "*Productus inflatus*," *Martinia contracta*, and *Chonetes chesterensis*. Stuart Weller correctly correlated the type Cypress Sandstone of south-central Illinois with the Ruma Formation, which lies between the Paint Creek and the Okaw in southwestern Illinois. The Beech Creek is very thin and poorly exposed in southeastern and south-central Illinois, but S. Weller (1920b, p. 185-187) found it at one locality in Johnson County, south-central Illinois, above the Cypress. Here he collected the faunas of both the Fraileys Shale and the basal Okaw (Beech Creek). This substantiated his correlation of the basal Okaw with the lower part of the Golconda and led him to disregard the early Chesterian aspect of much of the fauna. Actually, the fauna of the Beech Creek does not contain the forms considered most characteristic of either the Gasperian or the overlying Hombergian except for the brachiopod *Chonetes chesterensis*, which is known only from the Gasperian. However, the early Chesterian aspect of the Beech Creek macrofauna favors assignment of the formation to the Gasperian. The conodont fauna of the Beech Creek also differs from that of the overlying Fraileys and Haney (Rexroad and Burton, 1961).

The bryozoan *Cystodictya labiosa* and the species of the crinoid *Talarocrinus* with inflated plates and correspondingly incised sutures are the most definitive Gasperian fossils. Other fossils of help in recognition of the Gasperian or portions of it are evaluated in J. M. Weller and Sutton (1940), Malott (1952), and McFarlan et al. (1955).

Illustrations and descriptions of the fossils appear in the older literature, in particular S. Weller (1920b), Ulrich (1917), and J. M. Weller (1931).

The name Gasperian was chosen because Gasper has priority over New Design, Girkin, and West Baden. Both the top and bottom boundaries of New Design would have to be revised in its type area, West Baden has been revived with a slightly different meaning (Gray et al., 1960), and Girkin was never clearly defined.

Hombergian Stage

The Hombergian Stage is here proposed to include those rocks younger than Beech Creek Limestone and older than the Tar Springs Sandstone. The name is derived from the Homberg Group of J. M. Weller (1939). It is equivalent to the rocks J. M. Weller and Sutton (1940) placed in the Homberg Group in Kentucky and Indiana, but differs in that it excludes the Cypress and Beech Creek Formations in Illinois. The type section in eastern Pope County, Illinois, is therefore revised to exclude these two formations. The unit consists of the Fraileys Shale, Haney Limestone, Hardinsburg Sandstone, Glen Dean Limestone, and their equivalents.

Hombergian strata, particularly some of the shaly limestones and calcareous shales, are very fossiliferous. Faunas are more varied than in other Chesterian units, and the faunal lists, particularly of the Glen Dean, are quite long. The combination of favorable environment and ease of collecting has undoubtedly resulted in the apparent restriction to beds of this age of some forms that actually had a longer range. An example is the distinctive bryozoan *Prismopora serrulata* which once was believed restricted to the Glen Dean but which now has been collected in many calcareous shales ranging from the Fraileys to the Kinkaid. There are, however, many forms that appear to be valid indices to the Hombergian (J. M. Weller et al., 1948). Some species of *Pterotocrinus* with distinctive, large, heavy wing plates are typical of the Hombergian, with several species being confined to rather

thin units within it (Sutton, 1934b). The brachiopod *Camarophoria explanata* first appeared at the base of the Hombergian but continued throughout the Chesterian.

Elviran Stage

The Elviran Stage is here proposed as the exact equivalent of the Elvira Group of J. M. Weller (1939). It includes all Chesterian rocks younger than the Glen Dean Limestone. The Glen Dean–Tar Springs boundary has been the only one seriously considered for its base.

There is a prominent unconformity separating the Elviran rocks of the Illinois Basin from overlying Pennsylvanian strata. The uppermost Elviran formations, the Kinkaid and Grove Church, are similar in their lithology and mode of origin to the other Chesterian limestone formations and differ from the overlying Pennsylvanian formations. Both have always been considered as part of the type Mississippian section and are so considered here. However, these formations may have been deposited contemporaneously with formations that in other areas are placed in the Morrowan Stage and considered early Pennsylvanian.

Elviran faunas are characterized by the common occurrence of *Composita subquadrata* rather than *C. trinuclea* of the earlier stages; *Eumetria costata* rather than *E. vera*; several species of *Pterotocrinus* whose wing plates have triangular outlines; slender elongate species of *Agassizocrinus* rather than broad spherical or olive-shaped ones; abundant *Sulcatopinna missouriensis*, of which only one or two specimens have been found in Hombergian rocks; and the presence of typical *Spirifer increbescens*. The primitive fusulinid *Millerella* is first found in late Elviran rocks.

ROCK STRATIGRAPHY

Rock-stratigraphic units are differentiated because of their lithologic character. They are the practical units of most local geologic work. The categories recognized are bed, member, formation, group, and

megagroup (supergroup). The formation is the basic unit.

The rocks considered in this report constitute 22 formations, of which 19 units are entirely Chesterian in age, one entirely Genevievian, one largely Genevievian but with some possible Chesterian, and one definitely both Genevievian and Chesterian. The formations fall into a pattern of alternating sandstone-dominated and limestone-dominated units. The formations, where it is convenient, are divided into members. Twenty members, occurring in eight formations, are named. One of the members is assigned to two different formations in different areas. Only three beds are formally named.

Some formations in the lower part of the section studied are grouped into larger units in certain areas because of their lithologic similarity. Five such groups are recognized, two in western Illinois and three in the eastern part of the state.

There are two megagroups in the section. The boundary between the Mammoth Cave Limestone Megagroup and the overlying Pope Megagroup cuts diagonally across the Genevievian and early Chesterian formations so that several of them are classed in one megagroup in one part of the region and in the other megagroup elsewhere. The Mammoth Cave also includes formations older than those considered here, but the top of the Pope Megagroup corresponds to the top of the Chesterian.

The oscillating or cyclic character of sedimentation during the Chesterian (fig. 5) and the rest of the late Paleozoic has been noted frequently. The typical Chesterian pairing of a clastic-dominated formation with a limestone-dominated formation was cited by Wanless (1947, 1950) as a type of cyclothem. However, the practice in the Chesterian has been to apply separate names to the deposits of each half cycle (or of an odd number of half cycles) rather than to name complete cyclic units (cyclothem). The presence of 20 cycles in the Genevievian and Chesterian is implied in the proposed classification, although for-

mal names are provided for both the sandy and limy halves of only 16 of these cycles. About eight more alternations are recognized informally in different parts of the basin and eventually may be formally named.

The smaller units of the classification generally reflect shoreline fluctuation (figs. 4, 5). The marine current and the shifts in the lower course of the Michigan River affect the classification of the larger units. They were responsible for the lateral changes that make it necessary to group and rank units differently in different areas. Because the river was far to the west during Genevievian and early Gasperian times, it is impractical to recognize in Indiana and Kentucky some of the clastic units that punctuate the sequence in Illinois. For instance, the Ste. Genevieve and Paoli Formations in Indiana correspond to five, the Ste. Genevieve, Aux Vases, Renault, Yankeetown, and Downeys Bluff, in Illinois. In the late Gasperian, the situation is reversed. Division of the Ridenhower Formation into three members is established for Illinois, but it is difficult to differentiate them in many parts of the state. Because the Michigan River was to the east during Ridenhower deposition, the three divisions are so distinct in Indiana and Kentucky that they are ranked as formations.

The eastern position of the Michigan River during the deposition of the Paint Creek and Okaw Groups makes these limestone-dominated units useful combinations for classification in western Illinois but of little use farther east where clastic interruptions are more significant. Conversely, the West Baden Group is a helpful generalization only near the Illinois-Indiana boundary where sedimentation was dominated by the Michigan River and where there is little or no limestone from the base of the Bethel through the Cypress.

In summary, the individual lithologic units in the Genevievian and Chesterian classification represent advances and retreats of the shoreline, whereas the regional ranking and grouping of these units reflect

variations in the position of the Michigan River.

BOUNDARIES OF ROCK-STRATIGRAPHIC UNITS

"In geologic situations common in other regions, but not in Illinois, lithic units are quite thick relative to their lateral extent, and many lateral changes in lithology are abrupt. Under such circumstances, many of the rock-stratigraphic units recognized are facies. On the other hand, in Illinois and surrounding states the lithic units tend to be thin relative to their lateral extent. Although vertical lithologic changes in the sequence are quite abrupt, the lateral changes are gradual. In this geologic framework, experience has shown that the most useful units are those whose lateral extent is emphasized. Attempts at narrow lateral limitation of formal rock-stratigraphic units have met with little success in this region, and an informal facies nomenclature has been more successful in describing the lateral differentiation." — Willman, Swann, and Frye, 1958.

Individual rock-stratigraphic units of the Genevievian and Chesterian vary regionally in their lithology. Clastic and limestone units alike are more clastic near the mouth of the Michigan River and less clastic remote from it. Limestone units that are thick, pure, and massive at the southeastern corner of the basin become shalier as they are traced northwestward. They grade into shaly limestone, calcareous shale, and eventually shale or even sandy shale with only thin calcareous or fossiliferous streaks. At the southeastern corner of the basin the positions of many major clastic formations are marked only by rather thin shaly or sandy limestone units in a sequence of otherwise pure limestones. Traced northwestward, these units become more clastic until they are represented only by thick, pure sandstone. The sequence of alternating clastic and limy units remains constant from region to region, while there is a marked but gradual regional change in the specific rock types that represent both the limier and the more clastic phases of each cycle. The appli-

cation of different names to lithologically distinct but laterally equivalent portions of each phase is generally prevented by the very gradualness of the lateral variations.

In contrast to the gradual nature of horizontal lithologic changes, vertical changes in rock type are relatively abrupt. In each local situation boundaries between successive limy and clastic units are chosen to provide a combination of the greatest lithologic integrity of the individual units and lithologic contrast between them. Boundaries should be simple in shape and easy to recognize. Although rock-stratigraphic units are based on lithology, surfaces surrounding rocks of a given composition seldom make good rock-stratigraphic boundaries. Rocks of differing lithologies interpenetrate in a pattern too complex for definition of practical units. For example, all Chesterian sandstone formations contain some limestone, and all but one or two Chesterian limestone formations contain some sandstone. Locally a boundary follows a bedding plane between two kinds of rock—for example, a limestone bed over a shale bed or a very sandy, silty shale over a calcareous bed. Traced laterally the character of one or both of the bounding beds may alter so that there is no longer sufficient contrast between them to provide a satisfactory boundary and the bounding plane must be offset to another bedding plane. Most such offsets or steps are so minor that they go unnoted, but some are of sufficient importance to affect the classification and nomenclature.

In general, the boundary between a limestone unit and an overlying clastic one rises from bedding plane to bedding plane in going from a region of high clasticity to one of low clasticity. The pairs of rocks adjacent to the boundary change lithologically from relatively clastic in the region of high clasticity to less clastic farther from the mouth of the Michigan River, paralleling the changes in the character of the entire units.

A clastic formation in its own region of high clasticity generally includes a number of massive, nearly pure, sandstone bodies, each 20 to 100 feet thick, several hundred

feet to a mile or two wide, and less than a mile to several miles long, with shale, siltstone, and thin sheet sandstone beds between the elongate bodies (Swann, 1951; Potter et al., 1958; Potter, 1962). Many of the elongate sandstone bodies have discordant bases that truncate other sandstone bodies in the formation, the surrounding shale and silty sandstones, and even the underlying limy deposits. Where the surfaces extend into the underlying formation, they are the obvious formational boundaries. Such surfaces have been described as unconformities. However, in most cases they do not extend beyond the limits of the individual sandstone bodies and cover only a small part of the total area. Moreover, the sandstone bodies and their discordant bases start from several different levels within the major clastic units. Widespread unconformities recorded in the early literature actually are composed of segments of several of these surfaces. Rock units defined solely in terms of these individual sandstone bodies and their discordant bases are too erratic in distribution and shape to be useful stratigraphic units.

The position of a formational boundary in gradational sequences will always be somewhat arbitrary. Geologists working from different viewpoints will disagree as to which position is most appropriate. In defining Chesterian rock units, emphasis is placed on the less abundant constituents, limestone and sandstone, rather than the more abundant shale. In the earlier work, sandstone was considered paramount in choosing formational boundaries that generally were placed at shale-sandstone contacts, and the shale between a sandstone and a limestone was classified with the limestone.

At present more boundaries are placed at the edges of limestone beds, in effect transferring shale from the limestone formations to the sandstone formations. Both practical and theoretical considerations have led to this change in emphasis. Because sandstone bodies are erratic in shape and distribution, structure maps based upon them and isopach maps of the intervals between them are impractical.

The concept that the sandstone formations had subaerial unconformities at their base and were nonmarine, as opposed to the marine limestone formations, can no longer be maintained. Most, and probably all, Chesterian and Genevievian sandstone units in the Illinois Basin contain marine fossils in their lower portions. Fossils can be found in many outcrops but are more readily recognized in thin sections of unleached subsurface cores. Channels in the delta area of a major pro-grading river are scoured not at the land surface but several tens of feet beneath sea level at effective channel base. Although they differ in detail because the Michigan River was pro-grading into shallow rather than deep water, the individual Chesterian sand bodies with their down-slope orientation and cross-bedding are analogous to bar fingers, and perhaps to pass and crevasse fillings of modern deltas.

The late nonmarine stage at the top of some Chesterian clastic units was of minor importance and could begin only after the clastic delta platform unit had been built up to sea level. Fossiliferous shale, poorly fossiliferous siltstone, and massive sandstone were part of the same pulse and were all largely deposited beneath sea level. Therefore, the reasons for classifying certain fossiliferous shales with limestone units rather than with sandstone units no longer seem as compelling as they once did.

Some methods of stratigraphic study are particularly sensitive to clastic content whereas others are more sensitive to carbonate content. Electric logs fall in the first class, and those who work with them tend to restrict limestone formations to only the most massive units and to expand the clastic formations to include calcareous shale and shales with thin limestone beds. The study of well cuttings, on the other hand, emphasizes the calcareous elements; therefore limestone units are expanded at the expense of clastic ones. Outcrop workers interested in marine fossils place fossiliferous shales with the limestones. A tendency in detailed mapping to restrict the limestone units to only the most massive beds is exemplified by the recent decision in Indiana to restrict the Glen Dean Limestone to the lower mas-

sive unit and include in the Tar Springs Sandstone the fossiliferous shales generally considered the most characteristic part of the Glen Dean (Gray et al., 1960). This restriction is not followed here and the fossiliferous limestone-containing shales at the top of the Glen Dean and Menard are retained in those units. However, the upper limits of the Downeys Bluff, Beech Creek, Haney, and Vienna Limestones, and of the two limestone members of the Kinkaid generally are placed at the top of massive limestone beds, despite the occurrence of fossiliferous shale above these beds. Decisions are based partly on tradition, partly on the character of the overlying and underlying units, partly on the ease of recognition of the boundaries, and partly on judgment as to the particular boundary that will best fit the needs of most users of the units.

GENEVIEVIAN AND GASPERIAN FORMATIONS, MEMBERS, AND BEDS

Ste. Genevieve Limestone

The Ste. Genevieve Limestone is the oldest formation considered in this report. It is characterized by oolitic and crinoidal limestone. It extends from the top of typically lithographic, cherty, and darker limestone assigned to the St. Louis Limestone up to the base of the Aux Vases Sandstone. The Aux Vases–Ste. Genevieve contact is chosen to provide the greatest contrast between limestone dominance and sandstone dominance. The Aux Vases is continuously present above the Ste. Genevieve in Missouri and Illinois and extends a short distance into Indiana and Kentucky. East of the eastern edge of the Aux Vases, the Ste. Genevieve Limestone extends upward and includes all Genevievian (i.e., *Platycrinites penicillus*-bearing) rocks up to the base of the Gasperian (i.e., *Talarocrinus*-bearing) Paoli and Gasper (Girkin) Limestones. Relations of the Ste. Genevieve to the overlying formations east of the edge of the Aux Vases are discussed following descriptions of the Aux Vases and Renault Formations.

The definition is a compromise between several traditional uses and between consistency in tracing bounding surfaces and consistency in lithologic composition. The formation is dominantly oolitic or crinoidal limestone, but such limestone occurs in all the adjacent formations and is dominant in some of them. Many other types of rocks are present in the Ste. Genevieve. The upper and probably the lower surfaces are not simple planes but include some abrupt vertical offsets or steps. The definition agrees with recent usage in most areas, but in the fluorspar district the Rosiclare Sandstone Member and the Levias Limestone Member are removed from the Ste. Genevieve and assigned to the Aux Vases and Renault Formations, respectively. In the Anna district, some parts of the Hoffner Member are assigned to the Aux Vases and some to the Renault, and the name Hoffner is abandoned. In the subsurface near the Wabash River the beds beneath the Aux Vases that in recent years have generally been called the "Aux Vases lime" are expressly assigned to the Ste. Genevieve rather than having an indefinite status between the two formations.

The Ste. Genevieve is tabular, extending laterally hundreds of miles with a thickness rarely exceeding 200 feet. But in its relations to other formations, the Ste. Genevieve might be considered chair-shaped or L-shaped, for it both underlies and is laterally equivalent to the Aux Vases Sandstone and to part of the Renault Formation. The horizontal bar of the L extends under the Aux Vases in the central, northern, and western parts of the Illinois Basin. The upright bar of the L is east of the east edge of the Aux Vases and extends up beyond it.

The eastern margin of the Aux Vases runs almost north and south from a few miles west of the northern end of the outcrop belt in Indiana to Princeton, Kentucky. At this line there is a step down to the west in the upper surface of the Ste. Genevieve that is equivalent to the combined thickness of the Aux Vases and of overlying Genevievian limestone beds. The depth of the step is generally about 10 feet but it ranges from less than 5 feet at the

north to as much as 30 or perhaps 40 feet near Princeton. West of this line four members may be recognized in the Ste. Genevieve, but all of them do not extend through the whole region. Ten to eighty feet beneath the base of the Aux Vases is a clastic wedge extending out toward the southeast that has been named the Spar Mountain Sandstone Member. The part of the Ste. Genevieve beneath the Spar Mountain is the Fredonia Limestone Member. A limestone unit immediately above the Spar Mountain is here named the Karnak Limestone Member. Beds intermediate in position and character to the Karnak and Aux Vases are here placed in the new Joppa Member.

Fredonia Limestone Member

The Fredonia is the lowest, thickest, and most characteristic member of the Ste. Genevieve. It is here restricted to beds below the Spar Mountain Sandstone Member rather than extending upward to the base of the Rosiclare. Although this appears a severe restriction of the term, it is in reality only recognition of the manner in which the Fredonia has been used in most regions. In the subsurface of the entire basin and in outcrops in Missouri, Indiana, and southwestern Illinois, the name Fredonia has never been used for beds above the Spar Mountain. In these areas the Spar Mountain has been misidentified as Rosiclare, and Fredonia has been applied only to beds beneath its base. The revision has meaning only in the fluorspar district. Here Fredonia until now has referred to all beds up to the base of the Rosiclare. Assignment of the Rosiclare to the Aux Vases therefore makes Fredonia in this meaning a useless synonym of Ste. Genevieve. The term can be brought into conformity with its use elsewhere by restricting it to the old "lower Fredonia" of the fluorspar district. The old "sub-Rosiclare sand" or "middle Fredonia" is the Spar Mountain Sandstone Member (Tippie, 1945), and the old "upper Fredonia" is here assigned to the Karnak and Joppa Members. Stability in nomenclature is served by retaining the name Fredonia with its boundaries unchanged in 40 or 50

counties at the expense of redefining it in three or four counties, even though the latter include the type section.

A bed of fossiliferous, rough-weathering chert near the base of the Fredonia has been named the Lost River Chert Bed in Indiana. It is identified in Kentucky, and may extend into Illinois.

The Fredonia generally is overlain by the Spar Mountain. South of the edge of the Spar Mountain, along or slightly north of the Ohio River, the Fredonia cannot be distinguished from younger limestone units in the Ste. Genevieve. Near the north edge of the basin the Fredonia appears to be cut out at a few places so that sandy beds assigned to the Spar Mountain lie directly on the St. Louis Limestone (Whiting, 1959). In parts of western Illinois and Missouri the Aux Vases cuts through the Spar Mountain, so that the Aux Vases directly overlies the Fredonia.

Spar Mountain Sandstone Member

The Spar Mountain Sandstone Member is the chief clastic interruption of the Ste. Genevieve Limestone. Along the northern margin of the basin it is 20 to 80 feet thick, and at some localities it is divisible into upper and lower sandy units separated by a middle limy or dolomitic unit. These units are not now named because there are many localities at which they cannot be identified. The Spar Mountain type locality is at the extreme southern tip of what is probably the upper and more extensive of the two sandy units within the member.

As was noted earlier, the Spar Mountain has commonly been called Rosiclare in outcrops in Indiana, Missouri, and southwestern Illinois, and in the subsurface of the entire basin. The Rosiclare is actually 60 to 70 feet above the Spar Mountain in the fluorspar district, which contains the type sections of both units. The term Rosiclare should be replaced by Spar Mountain for the sandstone in the Ste. Genevieve, but its widespread acceptance as an oil pay designation implies that replacement will be slow.

In outcrops in southeasternmost Perry County, Missouri, and in some areas in the

subsurface of western Illinois, the overlying Karnak Limestone Member pinches out and the Spar Mountain is directly overlain by the Aux Vases Sandstone. In this situation the Spar Mountain cannot normally be distinguished from the Aux Vases, and the entire sandstone section is assigned to the Aux Vases.

Karnak Limestone Member

In central and eastern Illinois, except for parts of the easternmost counties, the strata between the Spar Mountain and the Aux Vases fall naturally into two units. The lower of these is a massive, pure limestone 15 to 30 feet thick, which is here named the Karnak Limestone Member of the Ste. Genevieve Limestone. The overlying Joppa Member is about as thick but is much more variable in character, ranging from clastic rock indistinguishable from the Aux Vases in western Illinois to limestone indistinguishable from the Karnak in Indiana. The Joppa and Karnak share the same type section (fig. 6).

In a belt through the central part of Illinois from Moultrie County on the north to Johnson County on the south, the Karnak is a massive, high-resistivity limestone sharply differentiated from the low-resistivity clastic beds of the Spar Mountain and Joppa. In some places slight porosity near its middle has resulted in somewhat lower resistivity and a prominent self-potential peak. In this subsurface region the unit has commonly been called the Ohara lime and considered the top unit of the Ste. Genevieve. Despite uniform electrical character, lateral lithologic variation from quite pure oolite to crinoidal limestone to fine-grained limestone occurs within a very few miles on a local rather than regional pattern. The unit retains its character to the south and east but loses its identity where the Spar Mountain to the southeast and the lower portion of the Joppa to the east are replaced by limestones similar to the Karnak.

In Indiana subsurface the Karnak and Joppa together constitute the unit generally considered upper Ste. Genevieve. The type Levias is added at the top of these and the

three form the upper Ste. Genevieve or "Levias" of the Indiana outcrops. The Karnak cannot be isolated from the rest of the Ste. Genevieve in central Kentucky. In the fluorspar district it is the lower half of the unit formerly called "upper Fredonia." It

F.M.	MEM.	JOPPA-KARNAK TYPE SECTION	
REN.	Lev- ias		Limestone, oolitic, cross-bedded, sandy; few <i>Platycrinites</i> ; 5'
AUX VASES, 19'			Sandstone, leached, very fine, cross-bedded, 4'
			Ls., oolitic, sandy, hematitic, 1'
			Covered; sandstone poorly exposed east of main outcrop; 14'
			Covered; some large slabs of crinoidal limestone; abundant <i>Platycrinites</i> near top; 14'
STE. GENEVIEVE	Joppa, 32'		Shale, gray; thin shaly limestone streaks; 7'
			Limestone, impure, dark, 1'
			Limestone, dark, coarse, 2'
			Shale, black, 6'
			Covered, 2'
	Karnak, 16' +		Limestone, partly oolitic, light to medium gray, crinoidal, cross-bedded, 16'

FIG. 6—Type section of the Karnak Limestone Member of the Ste. Genevieve Limestone and of the Joppa Member, which is assigned to the Ste. Genevieve in some areas and to the Aux Vases Sandstone in others. The lower part of the Karnak is poorly exposed in fields southeast of the junction of Illinois Highway 37 and a gravel secondary road leading eastward to Belknap. The major part of the Karnak is exposed in roadcuts on Highway 37 at the junction and on the secondary road about 500 feet east of the junction. The higher part of the section is exposed in the road ditch and hillside north of the secondary road about 300 feet east of the highway. The road junction is located half a mile east of the Chicago and Eastern Illinois Railroad at Joppa Junction and 4 miles northwest of Karnak. These exposures are in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 13 S., R. 2 E., and NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5, T. 14 S., R. 2 E., Dongola Quadrangle, Johnson County, Illinois.

is quite pure throughout the district, whereas the Joppa portion of the "upper Fredonia" may contain shaly streaks towards its base. In the Anna district the Karnak has been placed in the Hoffner Member in some outcrops but has been called Levias at most. The Karnak fails to reach the outcrops in southeastern Perry County, Missouri, and the Spar Mountain, as a consequence, cannot be distinguished from the Aux Vases and is included in it.

Joppa Member

During the 1940's it became apparent that the Aux Vases–Ste. Genevieve contact, picked purely on physical criteria, was being placed 20 to 30 feet higher in the subsurface of Indiana and Kentucky than in the central Illinois subsurface. The area of confusion was largely the two eastern ranks of counties in Illinois; west of there the contact was consistently placed at the lower horizon and east of there at the upper. At first several schemes were used by different companies to rectify their own records, but in the 1950's the unit between the two horizons generally came to be called the "Aux Vases lime." This unit is here given the formal name Joppa Member (fig. 6).

A limestone bed marking the top of the Joppa Member in the eastern three or four rows of Illinois counties changes into a series of lenses that occur sporadically farther west. Where this prominent limestone bed occurs consistently at its top, the Joppa is assigned to the Ste. Genevieve Limestone. The base can be distinguished as a shale or shaly limestone essentially to the eastern border of Illinois. The unit is thus a distinct and useful entity within the Ste. Genevieve in the eastern third of Illinois. It can be recognized in some parts of the central third of the state, where it is assigned to the Aux Vases. The Joppa is intermediate between the extensive pure carbonates of the Karnak and the relatively pure clastics of the main body of the Aux Vases.

Aux Vases Sandstone

In eastern Illinois and eastward into Indiana and Kentucky, the Aux Vases Sand-

stone is predominantly well sorted, calcareous, and very fine-grained sandstone which grades into siltstone. Porous, permeable lenses of this rock, typically 25 feet thick, a quarter of a mile wide, and three-quarters of a mile long, are surrounded by tight, shaly sandstone or silty shale of slightly lower porosity and much lower permeability. Red color is common in the tight phase, but the permeable sandstone bodies are white with relatively abundant pink and green grains. The Aux Vases is characterized by unusually low electrical resistivity. The sandstone in the eastern part of the basin is clearly marine and is overlain and underlain by beds containing characteristic Genevievian fossils. Although there is much more sandstone in the Aux Vases than in the underlying Ste. Genevieve and overlying Renault Formations, the sand in those formations is coarser than the sand in the Aux Vases.

The Aux Vases of eastern Illinois is exactly equivalent to the type Rosiclare Sandstone Member of the fluorspar district (Swann and Atherton, 1948), but no name other than Aux Vases is needed in this region. As the Aux Vases is traced westward, however, more units are incorporated in its base and perhaps its top. Some designation is needed to distinguish the main body of the Aux Vases (the part equivalent to the type Rosiclare) from these additional units. The term Rosiclare Sandstone Member is therefore retained, although the unit is assigned to the Aux Vases rather than to the Ste. Genevieve. Despite the widespread misapplication of the term Rosiclare to an older unit, the Spar Mountain Sandstone Member, it seems undesirable to introduce a new name for the unit that already had the name Rosiclare.

The east edge of the Aux Vases as a continuously recognizable stratigraphic unit runs almost north and south from a few miles west of the northern end of the outcrop belt in Indiana to Princeton, Kentucky. In the southern outcrop in Kentucky, the Aux Vases, commonly called Rosiclare, can be identified as far east as Hopkinsville in excellent exposures, but probably cannot be continuously mapped beyond Prince-

ton. The Aux Vases is commonly recognized and correctly identified in the subsurface to within about 20 miles of the Indiana outcrop. It reaches the outcrop belt in a very few localities in Indiana as a siltstone or sandy bed, not at the base of the Paoli where it generally has been placed (Malott et al., 1948; Malott, 1952; Perry and Smith, 1958) but 2 to 10 feet lower. This bed is in the base of the Bryantsville brecciation in some localities, but is beneath the Bryantsville at others (e.g., Perry and Smith, 1958, p. 51, bed 10).

In western Illinois the Aux Vases is much thicker than in eastern Illinois, due in part to the addition of more units at the bottom and perhaps at the top. Although the Joppa Member is largely limestone in eastern Illinois and is included in the Ste. Genevieve, in central Illinois the proportion of sandstone in the Joppa is higher so that the member is assigned to the Aux Vases—which therefore includes two members, the Rosiclare and the Joppa. In most of western Illinois the Joppa is not distinguishable by ordinary methods from the Rosiclare equivalent, although it generally is coarser and might be distinguished by precise grain-size determination (Swann et al., 1959).

In most of the subsurface of western Illinois and in some outcrops in the Chester district, the Aux Vases appears to rest on the Karnak. However, in outcrops in southeastern Perry County, Missouri, and in some places in the subsurface of western Illinois, there is no Karnak; only a solid sandstone section lies between the Fredonia Member of the Ste. Genevieve and the Renault. This is most clearly demonstrated in parts of Clinton and Washington Counties where the subsurface control is adequate to identify and trace the Karnak until it disappears. The entire section is called Aux Vases down to the base of the Spar Mountain. Where the control is too sporadic to permit bed tracing, the Aux Vases may contain one or more limestone interruptions, but it is generally impossible to tell in either subsurface or outcrop which of these represents which named unit in the Ste. Genevieve. Outcrops of this section

containing much limestone (e.g., at Alton in Madison County or at Andy's Run, NE $\frac{1}{4}$ sec. 1, T. 2 S., R. 10 W., Monroe County) have been called Ste. Genevieve, whereas the sequences in which limestone was not recognized have been called Aux Vases.

The Aux Vases is overlain by the Renault Limestone. The Renault becomes more clastic to the northwest, and in western Illinois and Missouri includes several sandstone beds. The lower of these are undoubtedly placed in the Renault Formation at some localities and in the Aux Vases at others. The eastern margin of the Aux Vases is overlain by limestone of Genevievean age assigned to the Renault. No rocks known to be Genevievean overlie the Aux Vases in the Chester district, and it seems reasonable that the basal Gasperian sandy zone, the Popcorn Sandstone Bed, is included in the Aux Vases in this region.

Renault Limestone

The Renault Limestone is the carbonate-dominated formation between the Aux Vases and Yankeetown Sandstones. In southeastern Illinois the time-stratigraphic boundary between the Valmeyeran and Chesterian Series and between the Genevievean and Gasperian Stages passes through the Renault. This also is the boundary between the two members, the Levias Limestone Member being the Genevievean part of the Renault and the Shetlerville Member being the Gasperian part. The term Levias is used for precisely the beds for which it was proposed. However, the original proposal placed these beds in the Ste. Genevieve Formation (Sutton and J. M. Weller, 1932), whereas they are here assigned to the Renault because they overlie the Aux Vases Sandstone. The name Levias has been used only for these rocks in the fluorspar area, but it has been used for older rocks, the Karnak and Joppa in some other areas, and it still is used in Indiana for a unit combining the Joppa and Karnak with the type Levias. The name Shetlerville is revived and modified by excluding the upper part of the type section, which is dominantly shale and is reassigned to the Yankeetown. The Shetlerville, too,

was originally considered older than the Renault (S. Weller, 1920a).

The Levias is generally lighter colored than the Shetlerville, with larger, better rounded, more nearly perfect, white or pink oolites that have small centers. The oolites in the Shetlerville tend to be smaller, more irregular, have films of hematite or clay between their laminae, and have larger centers that may be silt or sand grains or may be dark colored bryozoan fragments. These differences are somewhat local, for Shetlerville equivalents in west-central Kentucky include rocks indistinguishable from the Levias of southeastern Illinois. Dark brown fine-grained limestone also occurs interbedded with oolite in the Levias, particularly in the upper part. The upper few inches or few feet of the Levias are brecciated at many localities and form the Bryantville Breccia Bed. The basal few inches or few feet of the Shetlerville are siltier or sandier at many localities than either the Levias or the rest of the Shetlerville. This sandy zone grades into a sandstone bed here named the Popcorn Sandstone Bed (fig. 7) for an Indiana locality suggested by H. H. Gray of the Indiana Geological Survey.

In eastern Illinois the Renault ranges from about 10 to 15 feet thick at the north to 30 to 40 feet thick at the south, and is largely limestone with a minor amount of shale and very little sandstone. The Levias Member is continuous in the southeastern corner of the state but can be recognized only sporadically north of Lawrence County or west of Franklin County. In the subsurface of eastern Illinois and nearby Indiana and Kentucky, the Renault has commonly been called "lower Renault" in recent years, the "upper Renault" being the Downeys Bluff. The name Cedar Bluff Limestone Group is later proposed for the unit from the base of the Renault to the top of the Downeys Bluff.

In western Illinois the Renault is extremely variable in both thickness and lithology. The Levias Member generally cannot be recognized, and the Shetlerville Member ranges from 0 to 80 feet and includes as many as three or four alternations of sandstone and limestone units. The

lower of these sandstone units may be included in the Aux Vases at some localities. The "Renault sand" of some oil operators in the Salem pool, called "upper Aux Vases" by others, probably is equivalent to the Popcorn Sandstone Bed.

Discordant surfaces occur at the base of several units within the Renault and the adjacent formations, most abundantly in western Illinois and eastern Missouri but occasionally in other parts of the basin. Segments of several of these surfaces were treated as one surface in some earlier literature and cited as evidence for important pre-Aux Vases, pre-Renault, or pre-Chester unconformities.

Relations of the Ste. Genevieve and Overlying Formations East of the Edge of the Aux Vases

The eastern edge of the Aux Vases Sandstone as a useful unit runs nearly north from Princeton, Kentucky, to a little west of the northern end of the outcrop belt in Indiana. The Yankeetown above it extends only a little farther east. The Renault is not a useful unit beyond the limits of the clastic formations which bound it from Missouri across Illinois into western Indiana and Kentucky. East of those limits there generally is no basis, either paleontologic or lithologic, for differentiating the equivalent of the Levias from other Genevievian limestone beds that underlie it. The equivalents of the Shetlerville, Yankeetown, and Downeys Bluff are indistinguishable paleontologically and can be differentiated lithologically for only a short distance beyond the edge of the Aux Vases.

In general, the only practical division within the mass of oolitic and crinoidal limestones of Genevievian and Gasperian age is the paleontologically marked top of the Genevievian, which can be corroborated by minor local lithologic distinctions. The top of the Ste. Genevieve is therefore stepped up to this horizon at the eastern edge of the Aux Vases. The height of the step up to the east is equivalent to the thickness of the Levias and Aux Vases, generally 10 to 15 feet but ranging from 5 feet

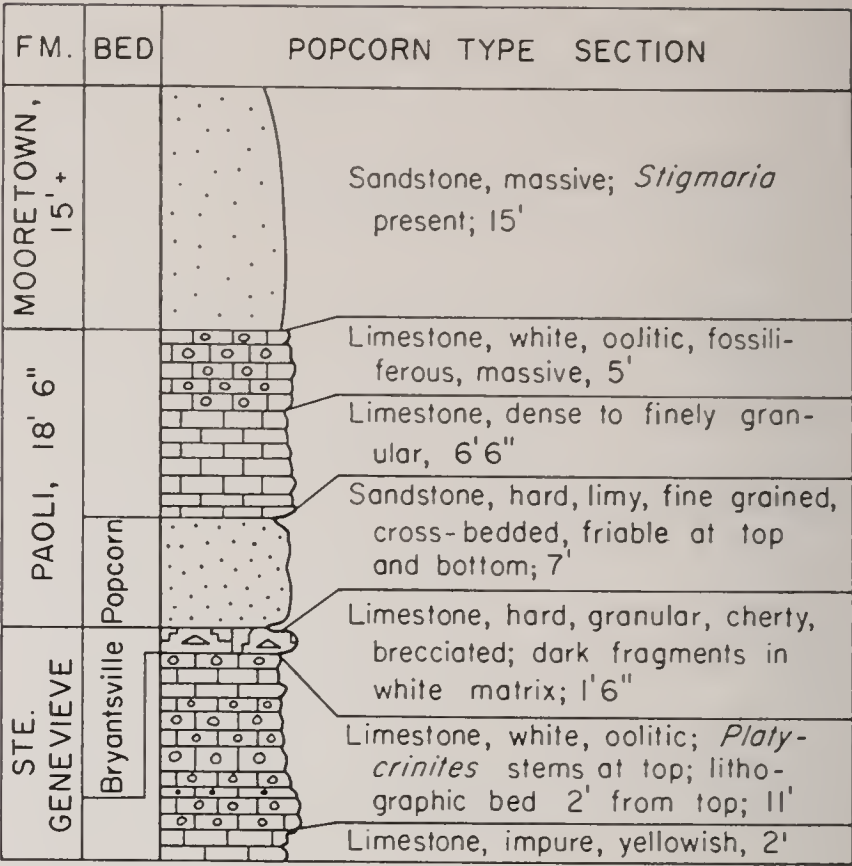


FIG. 7—Type section of the Popcorn Sandstone Bed, assigned to the Shetlerville Limestone Member of the Renault Formation in Illinois and to the Paoli Limestone in Indiana. The section is on a hillside about 50 feet above Popcorn Spring, 3½ miles northwest of Springville, about 700 feet west of Popcorn Church, and 200 feet north of the section line, SE¼ SE¼ SW¼ sec. 5, T. 6 N., R. 2 W., Owensburg Quadrangle, Lawrence County, Indiana. Section modified from Malott (1952, p. 80).

or less at the north to about 35 feet near Princeton. Westward the Levias is placed in the Renault because it overlies the Aux Vases. Eastward the equivalent of the Levias, being indistinguishable from the underlying limestones, is included with them in the Ste. Genevieve Limestone. Westward the Shetlerville is combined with the Levias as the Renault Limestone, which is underlain and overlain by clastic units. Eastward the Shetlerville is united with younger Gasperian units, largely limestone, to form the Paoli Limestone where the Bethel Sandstone is reasonably well developed. Where the Bethel is poorly developed or missing, the limestone unit is extended upward to include the Beech Creek equivalent and is named the Gasper or Girkin Limestone.

In field practice the contact between the Ste. Genevieve and the overlying Paoli or Gasper is commonly determined paleontologically. All limestones containing *Platy-*

crinites penicillus are placed in the Ste. Genevieve, while those containing *Talarocrinus* are placed in the Gasper or in the Paoli and higher Gasperian units. Because these fossils generally can be recognized only on weathered surfaces, recognition of the boundary in the subsurface of this region is much more difficult although not impossible.

The lithologic characteristics useful in distinguishing Ste. Genevieve from Paoli or Gasper are minor and many can be used only locally. Individual beds of particular varieties of oolitic or dense, fine-grained limestone (vaughanite) at or near the boundary can sometimes be traced for many miles. Criteria listed for distinguishing the Levias and Shetlerville Members of the Renault are useful for some distance farther east. At several points on the southern outcrop, between Princeton and Mammoth Cave, the lower beds of Gasperian age contain sparse, small, black chert nodules that are lacking in the top of the Ste. Genevieve. Conversely, in parts of the Indiana outcrop the top bed of the Ste. Genevieve contains beekite-type chert which replaces oolites and fossils and which does not occur in the basal Paoli.

The Bryantsville Breccia Bed was well described by Perry and Smith (1958). It marks the top of the Genevievian not only in Indiana but at many localities in Kentucky and some in Illinois. However, it must be used with some caution because similar breccias occur at several horizons toward the southeast corner of the Illinois Basin. They are particularly abundant and well marked along the eastern flank of the Cincinnati Arch where they occur at positions within and at the top of both the Ste. Genevieve and Paoli and also at or near the top of the equivalents of the Beaver Bend and Reelsville. However, the Bryantsville is far more extensive than any of these other brecciated zones, at least along the western flank of the arch.

I know of no lithologic distinction between the Ste. Genevieve and Paoli in the southern part of the Stephensport district. However, the Paoli as reported by Stouder

(1938, 1941) seems thin, and the contact may be picked too high. The spiny elliptical stem fragments of *Platycrinites penicillus* might possibly be considered as distinctive lithologic constituents of the Ste. Genevieve. Gray et al. (1960), who described these columnals carefully but scrupulously avoided applying their biologic name, so considered them.

The Popcorn Sandstone Bed marks the base of the Paoli in Indiana north of the Stephensport district and westward into Illinois. It is replaced by somewhat silty or sandy limestone that becomes purer toward the southeastern corner of the basin. The silt or sand content of the basal Paoli is a useful criterion in only part of the region.

Yankeetown Sandstone

The Yankeetown Formation contains prominent sandstone bodies only in the western part of the basin, where it reaches thicknesses as great as 60 to 80 feet and is commonly called the Benoist sand. In its type region in the northern part of the Chester district, the fine-grained, calcareous sandstone generally is leached and cemented by cryptocrystalline quartz into an irregularly bedded, white-weathering chert with floating sand or silt grains. The formation is represented in eastern Illinois by 20 to 40 feet of shale which thins and becomes limy eastward. In the Indiana outcrop it forms the thin, shaly middle member of the Paoli Limestone.

Downeys Bluff Limestone

The Downeys Bluff Limestone has been of prime importance in the correlation of Gasperian units. Dana and Scobey (1941) called it the "pink crinoidal" and traced it from the lower part of the Paint Creek in western Illinois through the "upper Renault" of eastern Illinois, into the top of the "Ste. Genevieve" of the Owensboro district, Kentucky, and nearly to the Indiana and Kentucky outcrops where it is at the top of the Paoli.

The formation varies from about 30 feet of limestone in the Princeton, Kentucky, district to a few feet of shale with thin lime-

stone layers in the northwestern part of the basin. Light gray crystalline limestone with pink or orange chert replacing fossil fragments is the most diagnostic lithology. It occurs largely toward the top of the formation at most localities in western Illinois, some in eastern Illinois, and a few in Indiana and Kentucky, although the chert that far east is more likely to be light milky gray than pink or orange. A double-peaked resistivity log is very characteristic of the unit in Kentucky and southwesternmost Indiana. The limestone responsible for the upper of the two peaks becomes shaly northward and the top of the formation probably is offset down a few feet to the top of the lower unit near Wabash County, Illinois.

Direct tracing of the Downeys Bluff from western to eastern Illinois made the correlation of the Yankeetown beneath the Downeys Bluff and the Bethel above the Downeys Bluff untenable. To retain the names Renault and Paint Creek in their original sense, as they still are used in western Illinois (i.e., Renault-Yankeetown-Paint Creek), is more conservative than to redefine them to fit current usage in eastern Illinois (i.e., Renault-Bethel-Paint Creek). Renault is therefore used in this classification only for beds beneath the Yankeetown. The old "upper Renault" of eastern Illinois is given formational rank as the Downeys Bluff. The entire unit recently called Renault in the fluorspar district and much of Kentucky comprises the Shetlerville Member, the Yankeetown, and the Downeys Bluff of Kentucky, and is now the Paoli. The unit recently called Renault in the subsurface of eastern Illinois comprises the true Renault, the Yankeetown, and the Downeys Bluff, and is raised to group rank and given the name Cedar Bluff Group later in this report. In western Illinois the Downeys Bluff is the thin basal limestone unit in the Paint Creek Group. The Paint Creek is raised to group rank because it contains three formations, Downeys Bluff, Bethel, and Ridenhower.

Bethel Sandstone

The sandstones beneath the Downeys Bluff are best developed in western Illi-

nois, whereas the Bethel Sandstone and the next few succeeding sandy units are better developed in the central or eastern part of the basin. The Bethel is represented almost entirely by shale in western Illinois, including a prominent, very deep red, non-laminated claystone bed in the Chester district. Outcrops of this red bed led to the naming of Paint Creek, and the stream's name was applied to the rock section between the Yankeetown and the Cypress.

The Bethel is an extremely prominent sandstone in eastern Illinois, the western edge of Indiana, and the fluorspar district in Kentucky. Sandstone extends to the eastern outcrop in Indiana and Kentucky, but the unit there is less prominent than several of the younger sandstones. A coal bed a few inches thick in the upper part, although not at the top of the formation, occurs in Indiana and Kentucky, and is the most widespread Chesterian coal in the Illinois Basin. It was named the "Shot Pouch Coal" over a century ago (Owen, 1856).

The Bethel Sandstone has been widely miscorrelated both in outcrop and subsurface with the older Yankeetown Sandstone of western Illinois and the younger Sample Sandstone of Indiana and Kentucky. The synonym Mooretown has been abandoned in Indiana but may still be needed in the Stephensport district of Kentucky, where the term Bethel has long been misapplied to the younger Sample Sandstone.

Ridenhower Formation

The name Ridenhower is revived for the complex and variable unit between the Bethel and Cypress Sandstones that generally has been called Paint Creek in eastern Illinois and upper Paint Creek in western Illinois. Ridenhower was originally proposed for this unit (Butts, 1917) but was dropped in favor of Paint Creek when the miscorrelation of Yankeetown to Bethel made it appear that Ridenhower (between Bethel and Cypress) and Paint Creek (between Yankeetown and Cypress) were synonyms.

Along the eastern margin of the basin in Indiana and Kentucky the interval between the Bethel (Mooretown) and the type Cy-

press (Elwren) comprises three readily differentiated units, the Beaver Bend Limestone, the Sample Sandstone, and the Reelsville Limestone, in ascending order. The sandstones—Bethel, Sample, and Cypress—thicken and become more massive westward. In a belt extending south-southwestward from the northern end of the Indiana outcrop to the fluorspar district, the Bethel, Ridenhower, and Cypress are essentially all sandstone and are placed in the West Baden Group.

West of this belt the Cypress and Bethel retain their relatively pure clastic characteristics, whereas the middle part of the section, the Ridenhower, consists of many interfingering sandstone, shale, and limestone units. The individual units extend only a few hundred feet or a few miles and have not been separately named. At many spots in eastern and central Illinois a rough zonation into a lower limestone-and-shale, a middle sandstone-and-shale, and an upper limestone-and-shale unit is possible, although it is hard to map these units consistently. The Indiana names Beaver Bend, Sample, and Reelsville are retained for these units but with member rather than formational rank. In eastern and central Illinois 50 to 75 feet of Ridenhower is commonly recognized, with the usual thinning to the north and with both thinning and increase in lime content to the west. Channeling at the base of individual sandstone bodies both in the Cypress and in the Ridenhower makes consistent application of names and tracing of boundaries in this part of the section very difficult.

The Ridenhower becomes increasingly limy to the southeast in Kentucky but is a useful unit along much of the southern outcrop until the virtual disappearance of the Bethel and Cypress force its incorporation into the Gasper (Girkin) Limestone.

Cypress Sandstone

The Cypress Sandstone is one of the thickest of the Chesterian sandstones. It is best developed near and just east of the center of the basin, where it is commonly over 100 feet thick and includes a complex of

massive sandstone bodies. In this region it is extremely difficult to recognize the base of the Cypress in many sections where it lies directly upon similar sandstones in the Ridenhower or perhaps truncates the Ridenhower entirely to rest on the Bethel. It thins somewhat and becomes largely shale at the eastern and western margins of the basin, where its equivalents have been named the Elwren and Ruma Formations, respectively. Marine fossils and even thin limestone units occur within the Cypress at several widely scattered localities and possibly at more than one stratigraphic level. Thin coal beds and underclays occur at several different levels within approximately the upper third of the formation. The Cypress is the most prolific oil-bearing formation in the Illinois Basin and is known by many different informal oil field terms in different areas. A miscorrelation of the Cypress with the younger Big Clifty Sandstone ("Indiana Cypress") has been corrected only in recent years, and the synonym Elwren may still be necessary to prevent confusion in parts of Indiana and Kentucky.

Beech Creek Limestone

The Beech Creek Limestone is a relatively thin but very persistent unit which is most useful in stratigraphic work and in structural mapping. It is generally darker colored than other limestone units with which it might be confused. It commonly has pellet or "pseudo-oolitic" structure. It carries two somewhat unusual faunas, one of relatively large brachiopods ("*Productus inflatus*" Zone) that are common in the upper part, and the other of small snails, small clams, and foraminifera (a "recurrent Salem" fauna) that are more abundant near the base. The unit was not formally named in the Kentucky, Illinois, and Missouri areas that supply most Chesterian names, and the Indiana section where it was named was miscorrelated with the rest of the basin. The unit's significance was recognized by many investigators who applied a wide variety of informal names to it—Barlow lime, *Productus inflatus* Zone, *P. i.* Zone, basal

Golconda, basal Okaw, brown dense-to-marly zone, brown pseudo-oolitic zone, and various numbers or letters. The only valid formal name is Beech Creek.

HOMBERGIAN FORMATIONS AND MEMBERS

Fraileys Shale

A unit 50 to 100 feet thick dominated by dark shale overlies the Beech Creek and has been named the Fraileys Shale. It is in turn overlain by a relatively massive carbonate unit, the Haney Limestone. Occasional limestone lenses within the Fraileys in eastern Illinois become more abundant toward the west and the unit is nearly a third limestone at the southwest corner of the basin. Red shale is uncommon in the eastern half of the basin but is fairly common in the western part, particularly in the upper third of the formation. The limestone and much of the shale in the Fraileys is very fossiliferous. Most of the fossils attributed to the Golconda from localities in Illinois and the fluorspar district of Kentucky have come from the Fraileys. Sandstone occurs sparingly in isolated lenses in eastern Illinois, particularly toward the north. It is much more abundant eastward and becomes the dominant rock type in parts of the Indiana and Kentucky subsurface where individual sandstone bodies reach thicknesses of 100 feet. The informal term Jackson sand is commonly applied to the sandstone in that area.

The sandstone in the Fraileys is the most prominent Chesterian sandstone in much of the outcrop area of Indiana and central Kentucky, where it has been named the Big Clifty Sandstone. The term Big Clifty is now used in Indiana and Kentucky for the entire unit between the relatively massive limestones of the Beech Creek and the Haney. At one time the term Indian Springs Shale was applied in Indiana to the upper part of the unit above the main body of massive sandstone. In Illinois, the term Big Clifty is reserved for the sandstone phase, which is classified as a member within the Fraileys.

The Big Clifty Sandstone was named in 1876, but it generally has been miscorrelated and called Cypress. The error in outcrop correlation occurred in the Princeton, Kentucky, district, and the terms Cypress and Golconda had different meanings on either side of Princeton. Westward, in Illinois and in the fluorspar district in Kentucky, the Golconda was well over 100 feet thick and included the units here called Beech Creek, Fraileys, and Haney. From Princeton eastward in Kentucky and in Indiana the Beech Creek was considered a formation and was correlated with the Paint Creek, the Big Clifty or Fraileys was called Cypress, and only the Haney, 50 feet thick or less, was called Golconda. Three formations in Indiana were thus equivalent to one, the Golconda, in Illinois. The three units are now recognized as distinct formations in Illinois as well as in Indiana, and Golconda is therefore raised to group rank. Because the lateral change in character from a sandstone-dominated to a predominantly shale unit corresponds quite well with the state line, Fraileys Shale is used in Illinois (McFarlan et al., 1955) as equivalent to Big Clifty Sandstone in the other states. It replaces "middle Golconda" or "Golconda shale" as differentiated from "Golconda lime" (Haney) and "basal Golconda" (Beech Creek).

Haney Limestone

The Haney Limestone is a relatively massive limestone formation containing moderate amounts of shale. It ranges from about 80 feet thick at a few places along the southern outcrop belt to a few feet at its northern margin in the subsurface. It is largely fossiliferous, somewhat crinoidal limestone and contains much oolite, particularly along the western margin of the basin, and some chert, particularly at the eastern margin.

The Haney generally has been called "Golconda lime" or "upper Golconda lime" in Illinois but comprises the entire section that generally has been called Golconda in Indiana and Kentucky. Lithologically it is quite similar to the Glen Dean Lime-

stone but can be distinguished from it paleontologically and by local lithologic criteria. It generally is lighter in color than the Glen Dean in the same region.

Hardinsburg Sandstone

The Hardinsburg Sandstone is best developed at or just east of the central part of the basin, where it contains much sandstone and is typically 60 to 100 feet thick but reaches 200 feet in a few small areas. Both east and west of the area of maximum development it becomes much shalier, particularly to the west where in the Chester district it is represented at some places by 20 feet or less of shale with thin limestone and dolomite interbeds and few or no sandstone layers. Several very thin coal beds are known, largely in the upper part of the formation in the central region. Red shale occurs most abundantly toward the eastern and western margins of the basin.

Glen Dean Limestone

The Glen Dean Limestone at the top of the Hombergian is one of the best known and most widely recognized Chesterian units. In the fluorspar district it is represented by about 60 to 70 feet of limestone, with thin shale beds particularly in the middle 20 or 30 feet. Shale is much more abundant elsewhere, being particularly common in the upper and middle part to the east and north, and in the middle and lower parts to the west.

In much of Indiana and Kentucky and part of eastern Illinois, a division into a lower massive limestone unit and an upper shaly unit containing both thin limestone beds and minor sandstone bodies would be possible. The Indiana Survey recently has restricted the term Glen Dean to the lower of these two units, placing the upper in the Tar Springs (Gray et al., 1960). The term "little lime" has been quite widely used in Kentucky for the lower massive unit. In some pools in the Owensboro district a limestone bed near the top of the upper unit has been called the "second brown lime" and a sand lens beneath it the "second Jett sand." These can be recognized

in the upper part of the type section of the Glen Dean. Although fossils occur in the lower massive unit, they are particularly well preserved and readily collected from the upper shaly unit, which has provided the largest known Chesterian fauna. In much of Illinois, the best division would be into three units, the upper and lower dominated by limestone and the middle containing much shale. The lower unit is the most massive in much of eastern Illinois, but the situation is reversed in many parts of western Illinois where the upper unit contains more limestone than the lower. Correlation of the internal stratigraphy of the Glen Dean is hampered because the upper part of the Glen Dean was removed from some critical areas by pre-Tar Springs erosion.

ELVIRAN FORMATIONS AND MEMBERS

Tar Springs Sandstone

The Tar Springs Sandstone is one of the most important clastic formations, more than 100 feet thick in much of the basin although less than 40 feet thick in the Chester district. It represents a complex series of depositional and erosional events. In some oil field areas separate upper, middle, and lower sandstone units have been recognized. In southeastern Illinois there are thin coal beds at the top of the formation and probably at two lower positions. The sandstone contains marine fossils at several localities in Kentucky. Thin limestone layers lie within the Tar Springs in Kentucky and Indiana, well above the level of the "second Jett lime" at the top of the Glen Dean. At many points the formation rests discordantly on the Glen Dean, and as much as 30 to 40 feet of the Glen Dean was eroded prior to Tar Springs deposition. At other localities, particularly along both the eastern and western edges of the basin, the Glen Dean and Tar Springs appear concordant and even gradational. The Vienna Limestone lies conformably on the Tar Springs in the southern two-thirds of the basin. Farther north dark shale and sandstones of the Waltersburg Formation rest

directly upon similar rocks of the Tar Springs. The two formations generally can be separated because the shales in the Waltersburg are softer and have lower electrical resistivity, but near the Indiana-Illinois state line, and probably in the Indiana outcrop area, their separation may be impossible.

Vienna Limestone

The Vienna Limestone is typically dark gray to brown, siliceous, and hard, and is notably cherty toward the south. Where outcrops are poor its position is marked by a zone of residual chert and silicified fossils. It is typically 5 to 10 feet thick, but reaches thicknesses of 15 to 25 feet along the southern outcrop belt. It thins northward to disappear at a ragged line that is a little north of the base line in most of Illinois and cuts diagonally across Indiana to the northern part of Perry County. In recent years the Vienna has been restricted, first in the subsurface but recently also in the outcrop, to a single massive unit or to two or three limestone beds with thin calcareous shales between them. Much shale that was formerly included with the Vienna is now assigned to the Waltersburg and Tar Springs Formations.

Waltersburg Formation

The Waltersburg Formation is largely dark shale, 35 to 80 feet thick, containing a striking series of elongated sand bodies. In the central and southern parts of the basin it lies between two thin but well marked limestone units, the Vienna Limestone and the Walche Limestone Member of the Menard Formation. The shale above the Walche is similar to that in the Waltersburg, and north of the northern limit of the Walche it is included in the Waltersburg, which then extends upward to the base of the Scottsburg Limestone Member of the Menard.

Menard Limestone

The Menard Formation is an alternation of limestone and shale beds that is less than 30 feet thick near its northern margin but

reaches 150 feet in the central part of the southern outcrop belt. In southeastern Illinois and the adjacent parts of Indiana and Kentucky, the formation consists of three well marked limestone units separated and overlain by units that are largely shale but contain thin limestone beds. The three limestone units generally have been called, in ascending order, the "little Menard," "massive Menard," and "upper Menard." They are here named the Walche, Scottsburg, and Allard Limestone Members. The type sections for the three members are shown in figures 8 and 9. Only the lower half of the Scottsburg Member is well exposed at its type locality, but the type sections overlap and all but the bottom three or four feet of the Scottsburg is exposed at the Allard type locality (Atherton, 1948). The unnamed shales between the named limestone members have more limestone interbeds toward the southwest corner of the basin. Although the members can be recognized there, they are much less distinctive than farther east.

The Walche Member thins northward from about 15 feet in the Princeton district to a feather edge which is near the base line in Illinois but cuts southeastward across southwestern Indiana to southern Meade County, Kentucky. The unnamed shale unit separating the Walche Member from the overlying Scottsburg Limestone Member ranges from 3 or 4 feet thick at the southwestern corner of the basin to 30 or even more feet thick at the northern edge of the Walche near the eastern outcrop. North of the edge of the Walche this shale is included in the Waltersburg. It is possible that the Chapman sand of the eastern part of the Owensboro district may lie in this shale member above the Walche rather than in the main body of the Waltersburg.

The Scottsburg contains the thickest and most massive beds of limestone in the Menard in the eastern and central parts of the basin but it becomes shalier to the west, whereas the Allard Member becomes less shaly in that direction. In the Chester district the Allard is the most massive member. Both the Scottsburg and Allard are

more than 30 feet thick along the southern outcrop belt, and the intervening shale member is nearly as thick. In the subsurface in the northern part of the basin the entire Menard becomes quite thin and shaly. There the Scottsburg is 15 to 20 feet thick but is largely shale, the limestone in it being reduced to 3 or 4 beds only a few inches to 2 feet thick. The Allard is reduced to two beds, or even a single thin

bed, of limestone and its top is only 10 to 15 feet above the top of the Scottsburg.

The top of the Allard provides an easily recognized plane useful for structure mapping and other purposes, and it is commonly used by the oil industry as the top of the Menard Formation. Although sandy strata lie directly upon, or even cut into, the Allard at many places, in most localities it is overlain by weak, low-resistivity, partly calcareous shale that contains thin limestone beds up to 2 or 3 feet thick. The shale ranges up to 35 or 40 feet thick. Its top is generally, though not always, recognizable on electric logs, the limestone in it is logged in most sample studies, and fossils from it are included in Menard collections. The Illinois Geological Survey is retaining it in the Menard as an unnamed member comparable in character and status to the unnamed shales between named limestone members. Somewhat similar shales above the Haney and Vienna are placed in the overlying sandstone formation. However, the boundary between this uppermost shale member of the Menard and the overlying Palestine can be traced more readily than could the upper boundary of the post-Vienna and post-Haney calcareous shales.

Palestine Sandstone

The Palestine Sandstone commonly is 20 to 40 feet thick but reaches 150 feet in a few wells in the central part of the basin. Where it contains well developed sand bodies, its lower surface cuts discordantly across the uppermost shale member of the Menard and into the Allard Member. In many areas the Palestine seems to represent only a single impulse of sand influx into the basin. In part of southeastern Illinois the situation is more complex. Un-

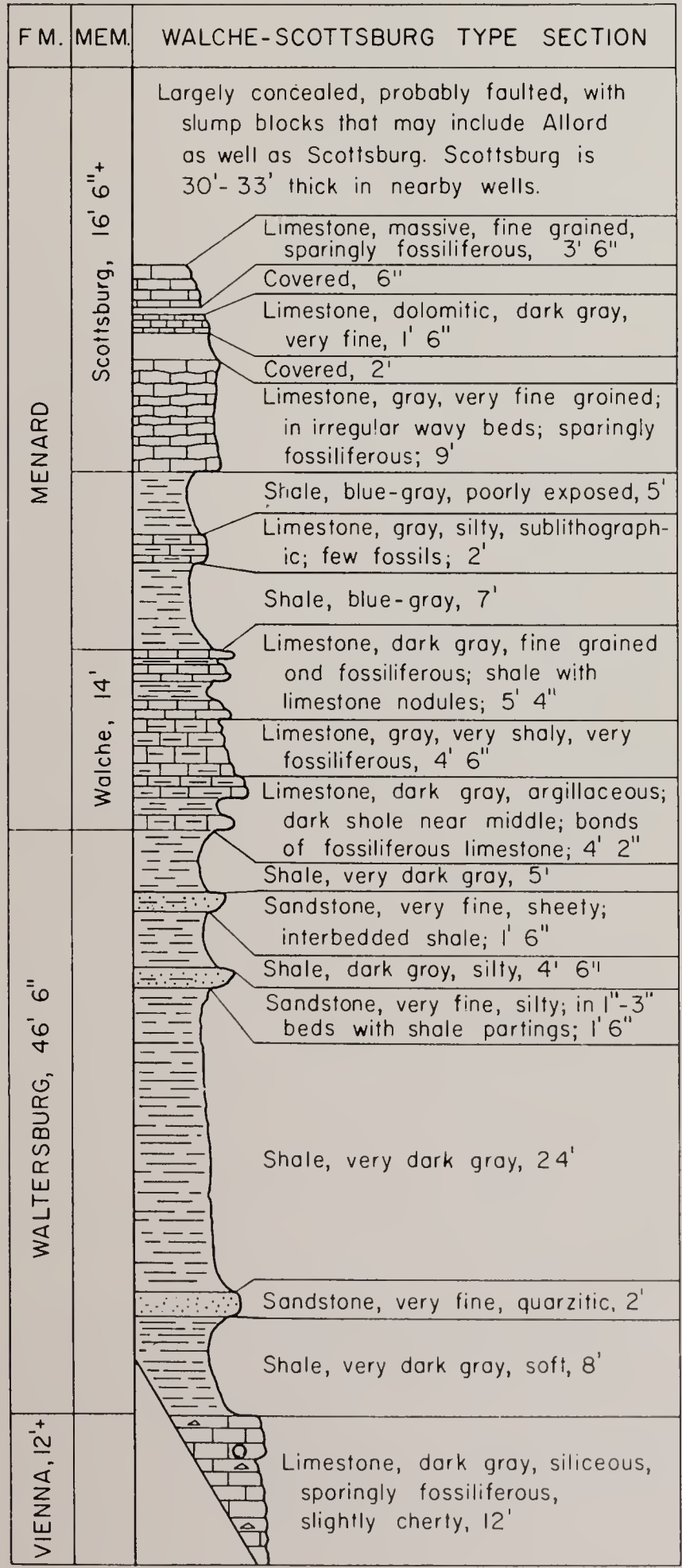


FIG. 8—Type section of the Walche and Scottsburg Limestone Members of the Menard Formation. The section is exposed in Walche's cut on the Illinois Central Railroad 3 miles northeast of Scottsburg and 3500 feet west of Claxton in the southwest corner of 19-H-21, 6400 feet from the south line and 8600 feet from the east line of H-21, Princeton East Quadrangle, Caldwell County, Kentucky.

published work by Atherton suggests that the upper surface of the Palestine is stepped down 10 or 15 feet in southeasternmost Illinois and Kentucky to the base of a thin limestone that interfingers into the upper part of the Palestine in most of Illinois. An underclay and coal bed mark the

top of the Palestine at several localities in western Illinois.

Clore Formation

The Clore Formation is complex. It is dominated by dark gray shale, interrupted by thin, variable limestone and sandstone beds representing probably as many as 7 or 8 alternations. In most areas it can be divided with reasonable success into upper and lower limestone-dominated units and a middle one in which sandstone is dominant. These are here named in ascending order the Cora Limestone, Tygett Sandstone, and Ford Station Limestone Members.

Although the Tygett is the most important sandstone unit in the Clore and reaches thicknesses of 50 feet, there are minor sandstone lenses in both the Ford Station and the Cora that reach thicknesses of 10 or more feet. In a few localities these sand lenses may be as prominent as the Tygett itself. The type sections for the members are shown in figures 10, 11, and 12, respectively.

Each member is typically about 30 feet thick. The formation ranges from about 50 to 110 feet thick. It is thicker than has commonly been reported, particularly in outcrop regions where it is poorly exposed because of its shaly character. The sandy sediments of the Tygett generally have been assigned to either the Degonia or the Palestine. Thus the reported thicknesses have been those of either the Ford Station or the Cora alone. The correlation of outcrops of Cora to those of Ford Station gave an exaggerated impression of the variability of the limestone and shale beds. In general the paleontologic characteristics ascribed to the Clore have been those of the Cora Member, and the lithologic characteristics have been those of the Ford Station Member.

The clearest demonstration of the three members of the Clore is in outcrops in Johnson County along Bradshaw Creek near the type locality of the Tygett Member, but there several sections must be used to complement each other. The type section shows the relation of the Tygett to the

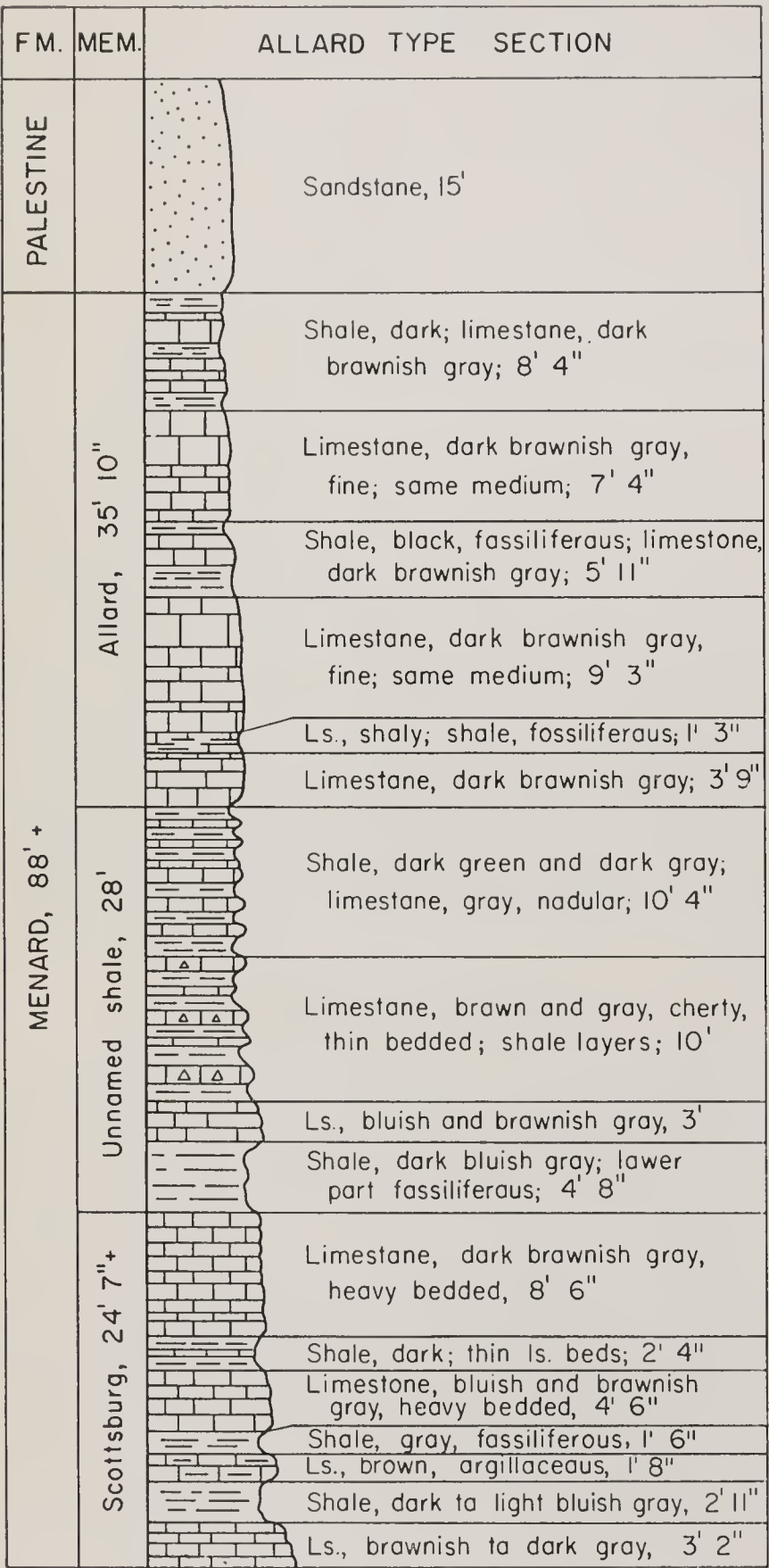


FIG. 9—Type section of the Allard Limestone Member of the Menard Formation. The section is exposed in the cut at the south end of a tunnel on the Illinois Central Railroad less than half a mile southeast of Flatwoods and 2.2 miles southwest of Allard College school, SW¼ NW¼ NE¼ sec. 1, T. 13 S., R. 4 E., Brownfield Quadrangle, Johnson County, Illinois.

Ford Station and Degonia very well, but the identification of the Cora is not convincing. The section along the Cobden-Lick Creek Road on the east bank of Bradshaw Creek, about a mile and a half below the type section, is not as well exposed as when Lamar (1925) described it. A gully about 300 feet south, near the east line of SW $\frac{1}{4}$ sec. 30, T. 11 S., R. 1 E., shows the succession of the major limestone, sandstone, and limestone units of the three members very well, but the shales are not exposed. About 2 miles farther down stream in the N $\frac{1}{2}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33 and SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 32, T. 11 S., R. 1 E., a valley entering Bradshaw Creek from the east shows the Tygett lying above an excellent exposure of the Cora, but the Ford Station is not well exhibited there. About 25 miles to the east a nearly complete section of the Clore is exposed in a cut on the Illinois Central Railroad at Robbs, NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30, T. 12 S., R. 5 E.

In general both limestone units in the Clore thin and become extremely shaly to the north. Because of this it is very difficult to identify them and thus to classify the entire sequence that lies between the Menard and the Kinkaid at the northern part of the basin. In much of Kentucky both the Degonia Formation and the Tygett Member of the Clore are shaly and contain some limestone so that it is difficult to separate them from the limestone members.

Degonia Sandstone

The Degonia Sandstone is best developed in the western part of the Illinois Basin, where it is a major sandstone 80 to 100 feet thick. Elsewhere it is half as thick and dominated by shale. Near the southern outcrop in Kentucky it contains so much limestone that it is distinguishable from the Clore only with great difficulty. Over much of the basin it exhibits some tendency toward a threefold division into upper and lower sandy units and a middle shaly, calcareous, or cherty unit. However, even in areas where many records show all three units, other records indicate that subdi-

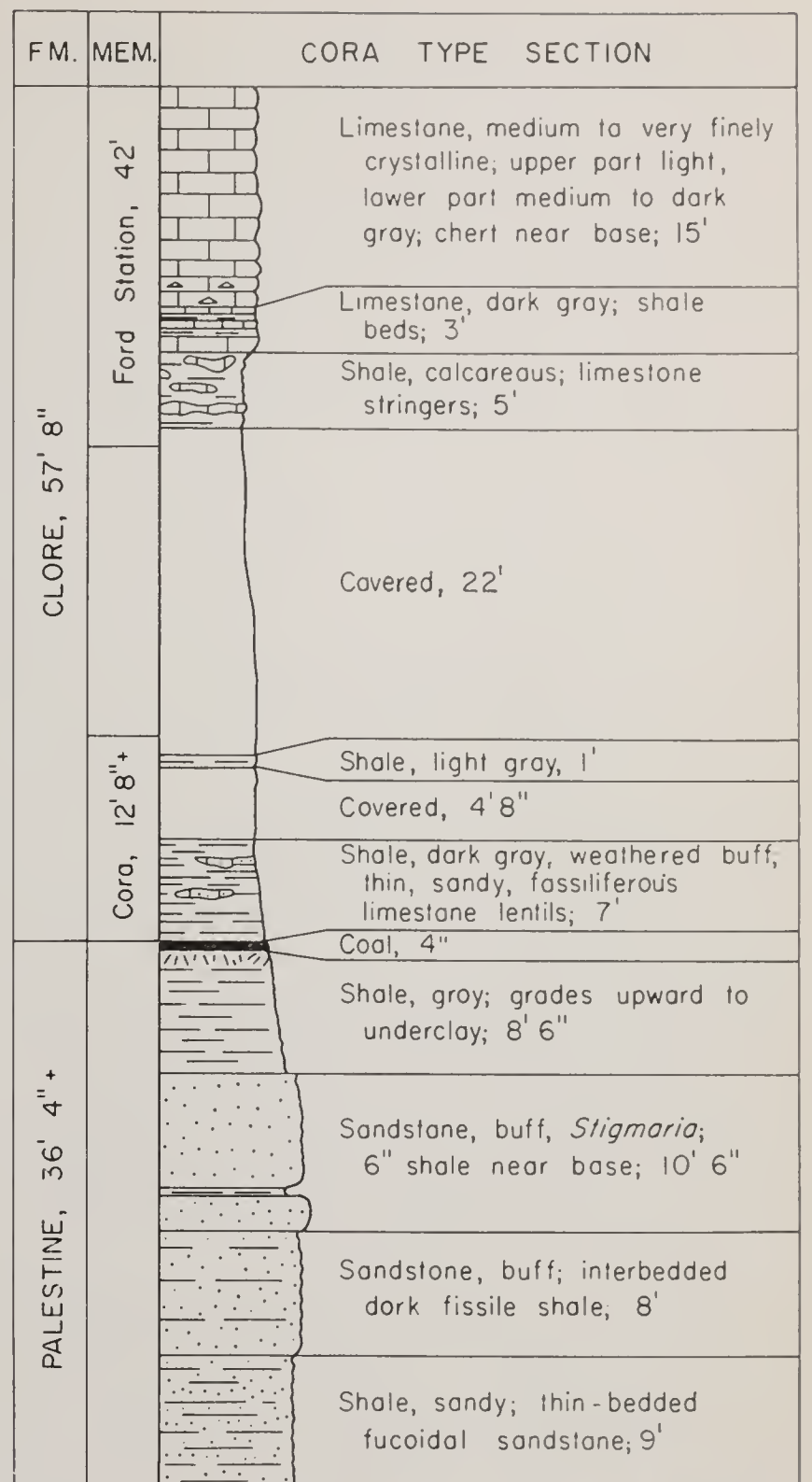


FIG. 10—Type section of the Cora Member of the Clore Formation. The section is exposed in the Mississippi Valley Bluff at the south edge of Degonia Creek Hollow a quarter of a mile north of Cora, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 16, T. 8 S., R. 5 W., Campbell Hill Quadrangle, Jackson County, Illinois.

vision is impractical. Consequently, the units are not formalized. Thin coal beds occur in the western area near the top and middle of the formation. In the fluor-spar district a bed of very siliceous, calcareous siltstone that grades laterally into chert marks the middle unit, or perhaps the upper part of the lower unit, and is of help in geologic mapping. A bed of red shale near the top of the Degonia is characteristic in many areas.

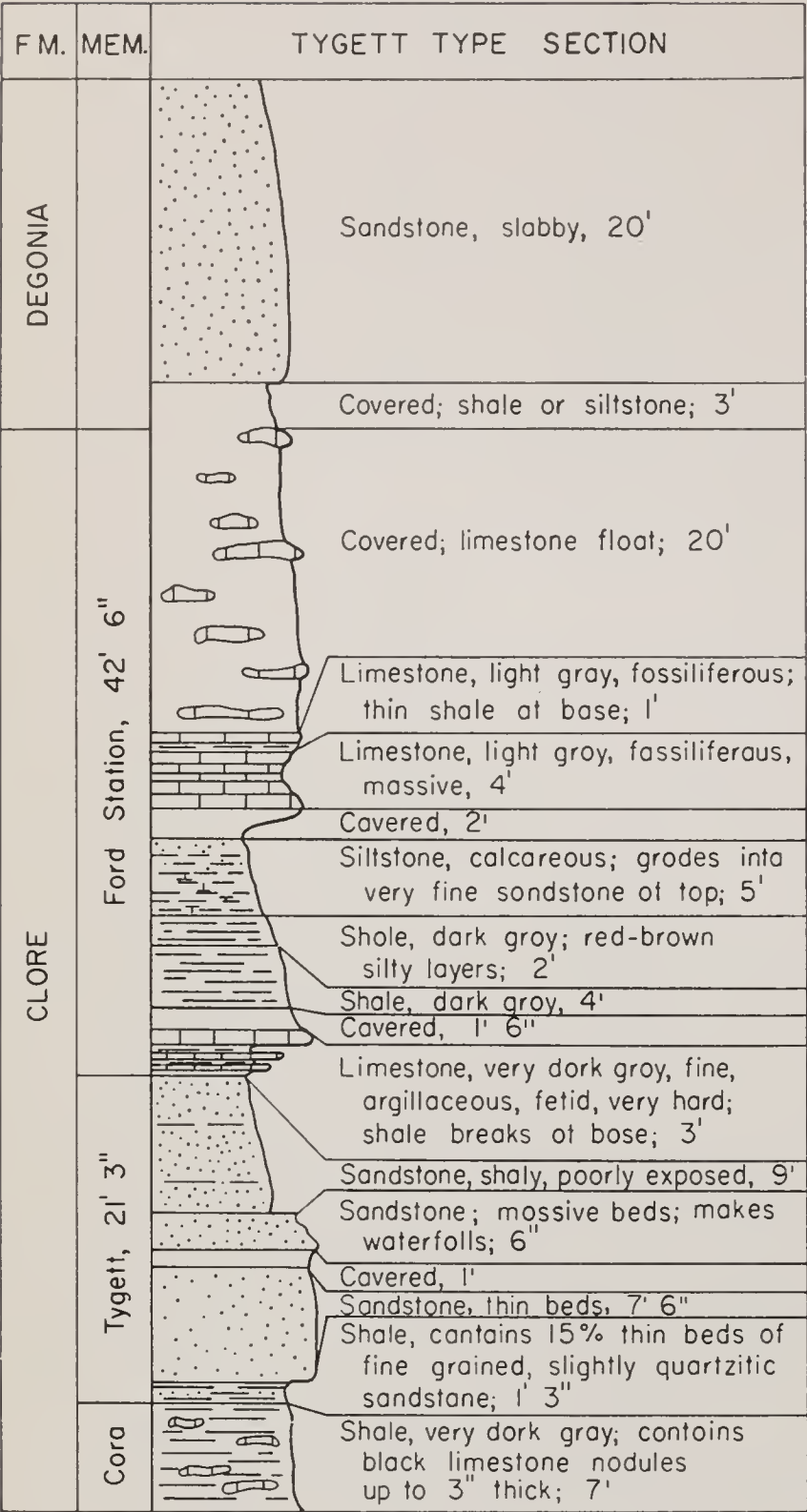


FIG. 11—Type section of the Tygett Sandstone Member of the Clore Formation. The section is in a stream bank and gullies on the south side of Bradshaw Creek 0.4 mile southeast of Water Valley school and 1.5 miles north of Tygett school. Near center of NE¼ NW¼ sec. 24, T. 11 S., R. 1 W., Carbondale Quadrangle, Union County, Illinois.

Kinkaid Limestone

The Kinkaid is perhaps the most readily identified of all Chesterian formations. Its top and bottom are marked by massive limestone units, each about 15 feet thick at the north and 30 to 40 feet thick at the south. The name Negli Creek (Malott, 1925) is revived for the Negli Creek Limestone Member, the lower massive unit. The middle member comprises shales and lime-

stones, generally 70 to 100 feet thick, and is here named the Cave Hill Member. The Cave Hill type section (fig. 13) is abnormally thick because of tectonic squeezing in the axis of the drag syncline bordering the Cave Hill Fault. The upper massive unit is here named the Goreville Limestone Member (fig. 14). Parts of all limestones in the Kinkaid are somewhat cherty. The Kinkaid is restricted here to these three members, and all Chesterian beds above the Goreville are placed in a new formation, the Grove Church Shale.

Negli Creek Limestone Member

The Negli Creek is a rather fine-grained light gray or brownish gray fossiliferous limestone. It can be recognized not only by its massive character, but by the common occurrence of algal growths (*Girvanella*) in

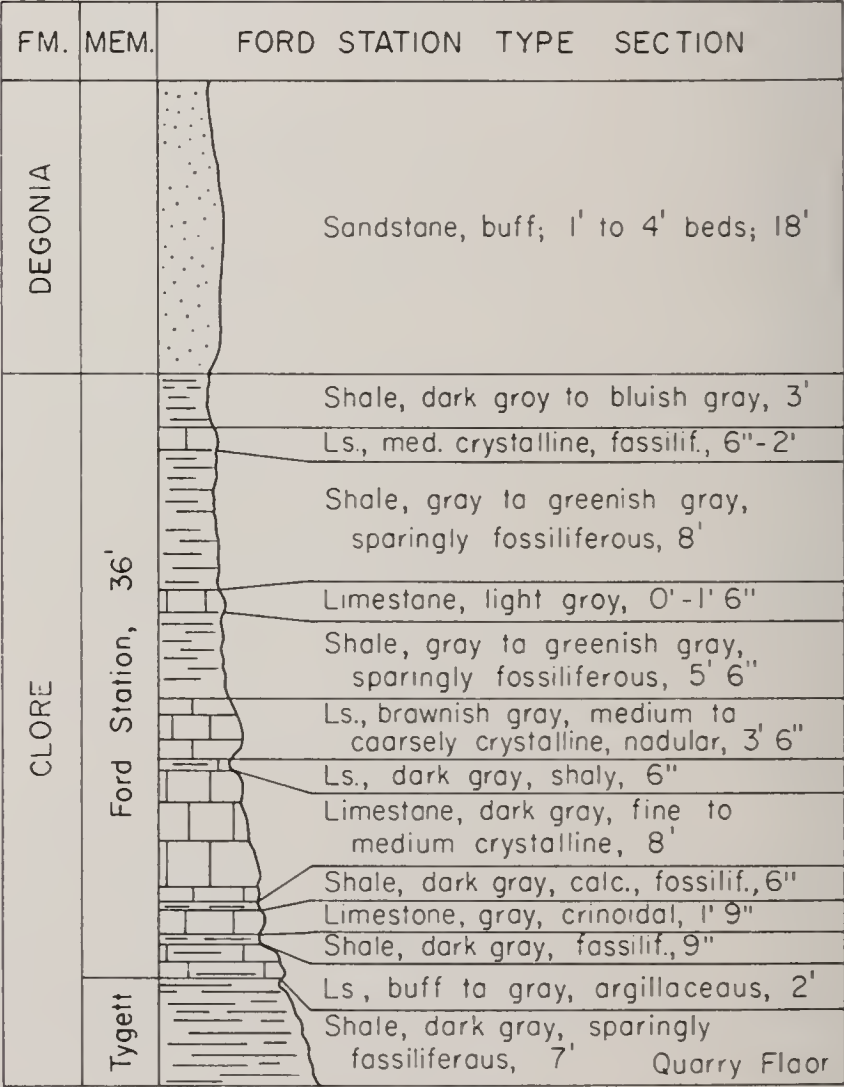


FIG. 12—Type section of the Ford Station Member of the Clore Formation. The section is in an abandoned quarry on the east side of Illinois Highway 3, but not visible from the highway, about 1¼ miles southeast of the bridge over Marys River and a quarter of a mile southeast of the Ford Station siding of the Missouri Pacific Railroad, NW¼ SE¼ sec. 33, T. 7 S., R. 6 W., Chester Quadrangle, Randolph County, Illinois.

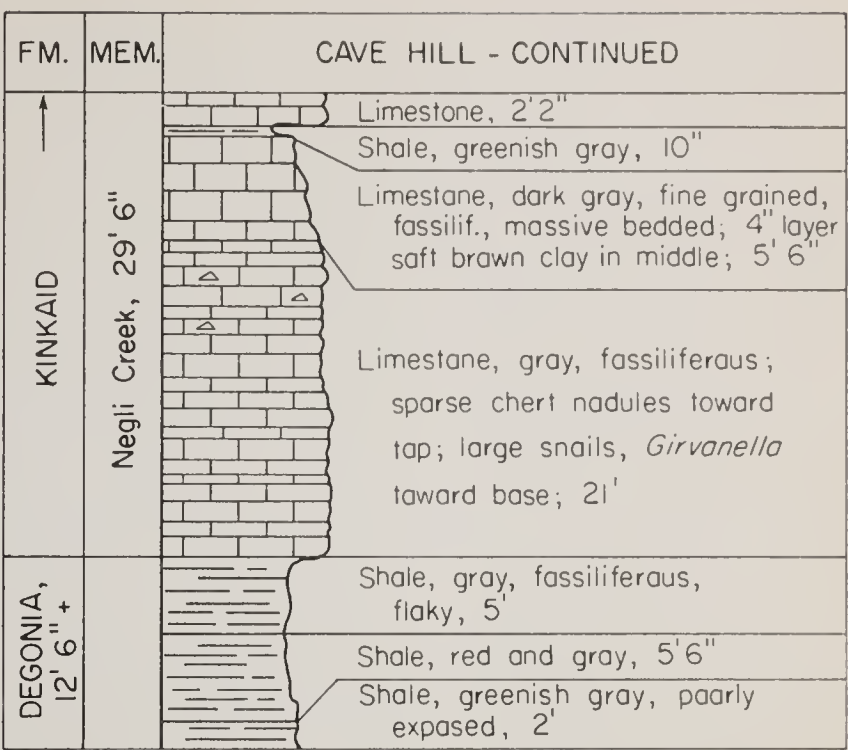
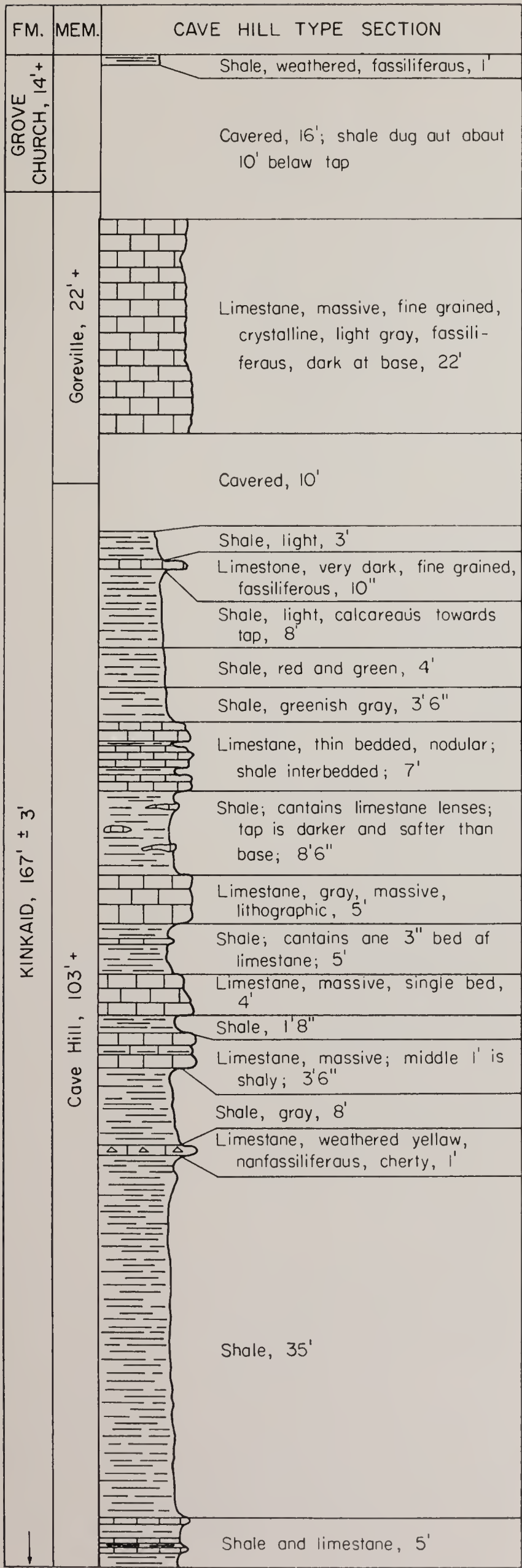


FIG. 13—Type section of the Cave Hill Member of the Kinkaid Formation. The section is in a roadside ditch and in stripping above an abandoned quarry on the west slope of Cave Hill about 4 miles northeast of Rudement, SE¼ SW¼ NW¼ sec. 3, T. 10 S., R. 7 E., Rudement Quadrangle, Saline County, Illinois. The section is tectonically thickened about 20 feet due to its position in the axis of a tight drag syncline. The Cave Hill Member is 85 to 90 feet thick in nearby wells. The base of the section strikes N 20° W and dips 20° SE, whereas the top is nearly flat.

the lower part and by large gastropods and small biserial foraminifera near the middle. The Negli Creek Limestone of Indiana was abandoned as a synonym of Kinkaid, but is here revived for the lower member, which is the only one that crops out in Indiana.

Cave Hill Member

Limestone is commonest near the middle part of the Cave Hill. At the southwestern corner of the basin, shale is restricted to the top and bottom few feet of the member. The lower part of the member contains some silt beds and even a trace of fine sandstone toward the northeast. There is a red shale bed near the top of the member, but the uppermost shale beds are commonly very dark gray to black.

Goreville Limestone Member

The Goreville is similar to the Negli Creek lithologically, but possibly is a bit finer grained. As outcrops are much more restricted than those of the Negli Creek,

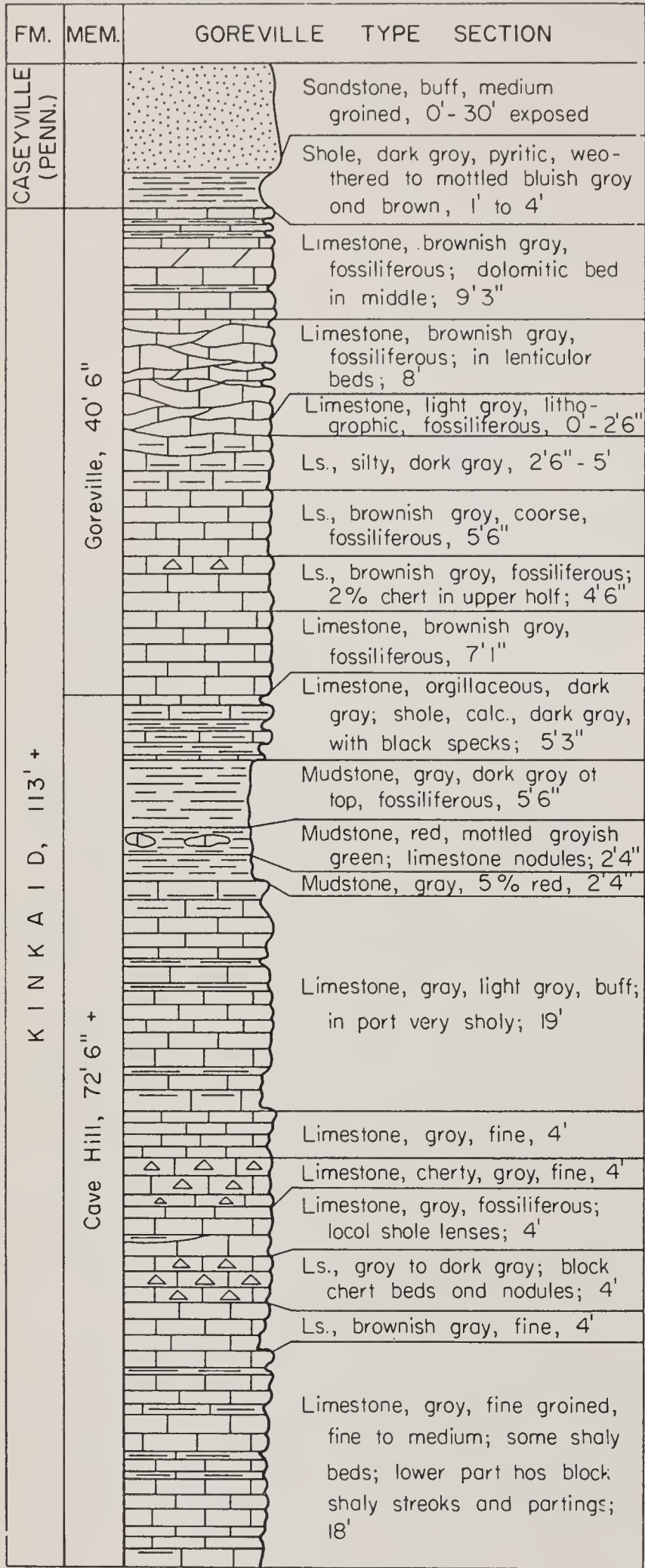


FIG. 14—Type section of the Goreville Limestone Member of the Kinkaid Formation. The section is in the quarry of the Southern Illinois Rock and Stone Company on the west side of Illinois Highway 37 at the north edge of Buncombe, 4 miles south of Goreville, SW ¹/₄ SW ¹/₄ SE ¹/₄ sec. 10, and NW ¹/₄ NW ¹/₄ NE ¹/₄ sec. 15, T. 12 S., R. 2 E., Vienna Quadrangle, Johnson County, Illinois.

the member is not as well known paleontologically.

Grove Church Shale

The Grove Church Shale is the youngest Chesterian unit in the Illinois Basin. The type section is the only well exposed outcrop known (fig. 15). The Grove Church is a dark gray, fossiliferous, marine shale containing a few limestone beds that generally are thin but may be as much as 5 or even 8 feet thick. A thin red shale streak occurs about 40 feet above the base in a few wells. The formation covers less than a thousand square miles in several patches that are isolated by pre-Pennsylvanian erosion and are scattered through six or seven counties in southeastern Illinois, two in southwesternmost Indiana, and possibly two or three in Kentucky. The maximum thickness of 65 feet is in the northern half of Johnson County, Illinois, where the formation has been found in about half of the drill holes. The type locality is near the western limit, and other outcrops that have not been differentiated from the Kinkaid may occur in the next 30 or 40 miles to the east in Johnson, Pope, and Saline Counties, Illinois. The formation was stripped by pre-Pennsylvanian erosion from the outcrop area in Hardin County, Illinois, and probably along the entire Kentucky outcrop.

The fauna of the Grove Church is distinctive and has been described by Cooper (1947) and Rexroad and Burton (1961). Although the formation is well differentiated lithologically from the underlying Goreville Member of the Kinkaid, two other factors influenced its recognition as a separate formation rather than as another member of the Kinkaid—the distinctness of its fauna from that of the restricted Kinkaid, and the widespread use of the name "upper Kinkaid" for the Goreville.

GROUPS

Two or more contiguous formations that have common lithologic attributes setting them apart from the formations above and below can be classed together as a group.

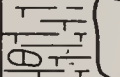
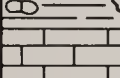
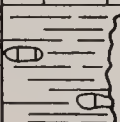
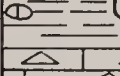
FM.	MEM.	GROVE CHURCH TYPE SECTION	
CASEYVILLE (PENN.), 29'+			Sandstone, massive to irregular bedded, fine to medium grained, 5'
			Shale, black, laminated to flaky, silty to sandy, micaceous, 19'
			Sandstone, thin bedded, fine grained, hard, white to greenish brown, 5'
GROVE CHURCH, 16'			Shale, calcareous, gray and dark gray, fossiliferous, 6'9"
			Limestone, shaly, fossiliferous; shale, gray; 3'6"
			Shale, gray, calcareous; limestone nodules; 5'9"
K I N K A I D	Goreville, 37'		Limestone, gray, very fossiliferous, 16'
			Shale, gray, poorly exposed, 2'8"
			Limestone, gray, massive, fossiliferous, 18'4"
			Shale, dark gray, partly concealed, 1'10"
	Cave Hill, 38'+		Limestone, gray, fossiliferous, slabby, 1'6"
			Shale, greenish gray, soft, partly concealed, 4'
			Shale, nodular, red, 4'2"
			Shale, greenish gray, with nodules of dense limestone, 4'
			Limestone, gray; nodular, dense; lower portion contains layers of shale; 10'
			Shale, light gray, with nodules of dense limestone, partly concealed, 10'6"
			Limestone, siliceous, gray; cherty bands; 2'

FIG. 15—Type section of the Grove Church Formation. The section is exposed in a roadcut and nearby gullies to the west of a nearly abandoned roadway that climbs the Caseyville escarpment about 0.3 mile northwest of Cedar Grove Church and 1¼ miles east of the village of Lick Creek, west line of the NE¼ NW¼ sec. 31, T. 11 S., R. 2 E., Carbondale Quadrangle, Johnson County, Illinois. Modified from Lamar (1925, p. 80).

Successive Chesterian formations represent opposing phases of cyclic deposition. Adjacent formations, therefore, tend to be so different that groups are less pertinent than in many other situations. This is particularly true of basin-wide groups, and none are recognized. However, in specific portions of the basin either the carbonate or the clastic portion of one or several cycles may be weakly developed. In these areas groups occur locally that consist of several prominent limestone formations with weak shaly interruptions or, conversely, of several strong clastic units with only minor limestones. Five such groups are recognized in Illinois, two in the western part of the state and three in the eastern. Several others occur in Indiana and Kentucky.

The same formation may be a component of several different groups in different areas. Thus the Ridenhower falls in the Paint Creek Group of western Illinois, in the West Baden Group of eastern Illinois and Indiana, and in the Gasper (Girkin) Limestone Group of the Mammoth Cave district. It might be considered a group in its own right in areas where its divisions have formational rank. Many units now considered groups were first described as formations or even members.

The Paint Creek Group consists of the Downeys Bluff, Bethel, and Ridenhower Formations in western Illinois where the Bethel is relatively thin and consists of shale with little or no sandstone. The group is nearly all limestone and shale between two formations, the Yankeetown and Cypress, which are notably more sandy.

The Okaw Group or Okaw Limestone Group of the Chester district, western Illinois, consists of the Beech Creek, Fraileys, Haney, Hardinsburg, and Glen Dean Formations in a region where the Fraileys is sand-free and includes much limestone and where the Hardinsburg is nearly sand-free and is quite thin. Actually, the five formations can be separated readily in normal subsurface records in the region. However, there are many outcrops of only a few feet of limestone or of limestone and shale whose assignment to the Glen Dean, Haney,

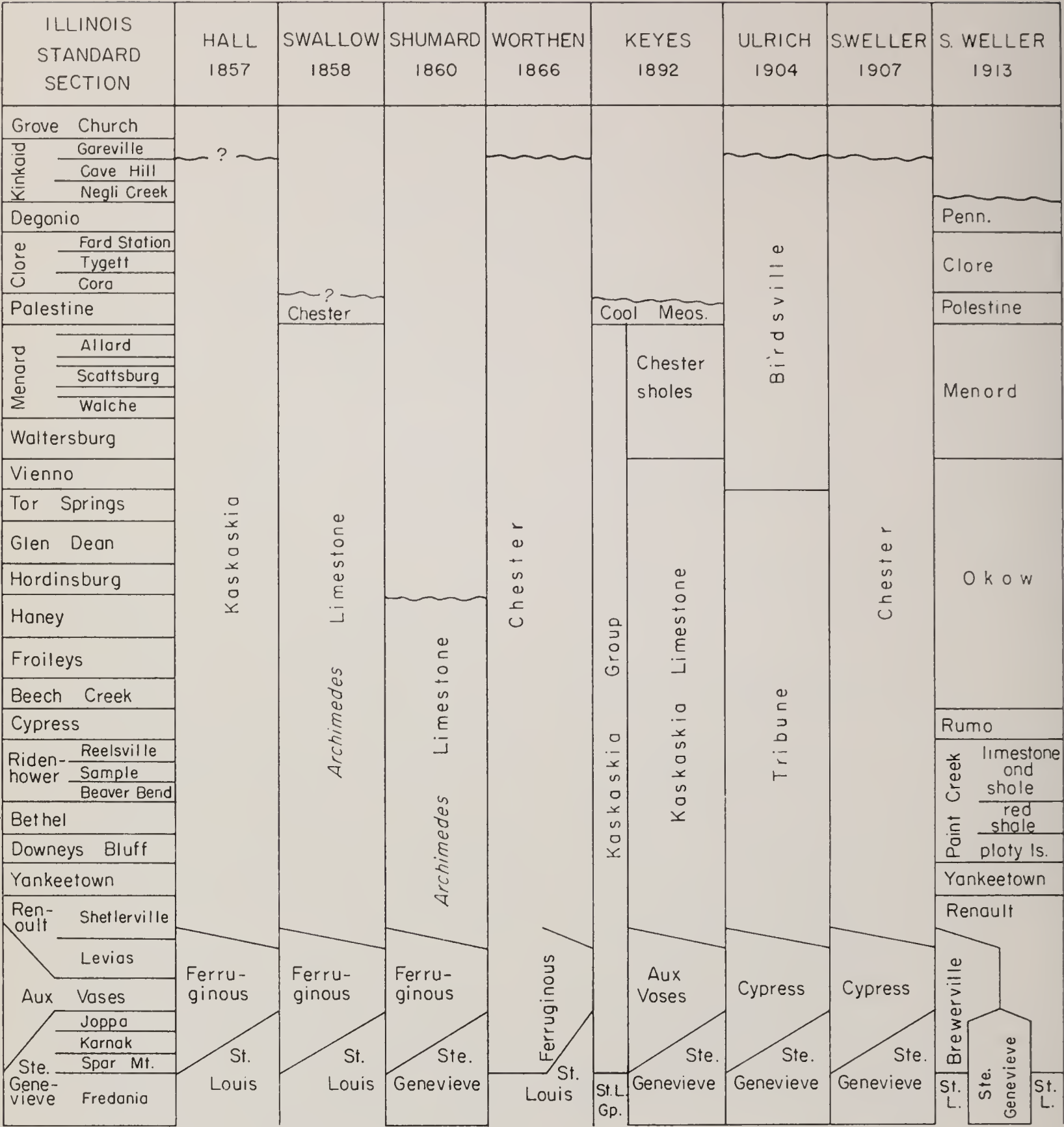


Figure. 16—Development of classification in

or limestone lenses in the Fraileys is uncertain. The Okaw is retained largely to accommodate such outcrops. Okaw has had several meanings. It originally included the Tar Springs and Vienna in addition to the five formations now placed in it, and at various times it also included the Cypress and the Waltersburg.

The Cedar Bluff Limestone Group is here named as an exact synonym of the Ohara as originally used by Ulrich (1905) and has the same type section, the Cedar Bluff (formerly Ohara) quarry near Prince-

ton, Kentucky. The group comprises the Renault (including both the Levias and Shetlerville Members), Yankeetown, and Downeys Bluff Formations in eastern Illinois and in the fluorspar district where the Yankeetown contains little or no sand and may include moderate amounts of limestone in addition to shale. It lies between the Aux Vases and the Bethel Sandstones. It is the unit currently called Renault in the subsurface of eastern Illinois, and its major use will probably be in the subsurface.

ULRICH 1917	S. WELLER 1920a	ULRICH 1922	S. WELLER & ST. CLAIR 1928	SUTTON 1934a 1934b	WELLER & WELLER 1939	J.M. WELLER 1939 STOPS 4-10,40-46	THIS PAPER	
	Kinkaid			Kinkaid	Kinkaid	Kinkaid	Kinkaid	Cave Hill
	Degania			Degania	Degania	Deg.	Degania	Negli Creek
Clare	Clore			Clare	Clare	(Stop 9) (Stop 10) Clore	Clore	Ford Station Tygett Coro
Palestine	Palestine			Palestine	Palestine	Palestine	Palestine	
Menard	Menard			Menard	Menard	Menard	Menard	Allard Scottsburg Walche
Glen Dean Hardinsbg.	Glen Dean Hardinsbg.			Waltersbg. Vienna Tar Sprgs.	Waltersbg. Vienna Tar Sprgs.	Waltersburg Vienna Tar Springs	Waltersburg Vienna Tar Springs	
Okaw	Okaw			Glen Dean Hardinsbg.	Glen Dean Hardinsbg.	Glen Dean Hardinsburg	Glen Dean Hardinsburg	
Prod. infl.	Okaw Limestone			Lower Okaw Golconda	Okaw Golconda	Golconda	Golconda	Haney Fraileys Beech Creek
Ruma	Cypress			Ruma	Ruma	Cypress	Cypress	
Paint Creek	Paint Creek			Paint Creek	Paint Creek	Paint Creek	Paint Creek	Ridenhower Reelsville Somple Beaver Bend
Yankeetawn	Yankeetawn			Yankeetown	Yankeetawn	Bethel	Bethel	Dawneys Bluff
Renault	Renault			Renault	Renault	Renault	Renault	
Aux Vases	Aux Vases			Aux Vases	Aux Vases	(Stp 42) Aux Vases	Aux Vases	
Ste. Genevieve	St. Louis Ste. Genevieve			Ste. Genevieve	St. L. Ste. Genevieve	St. L. Ste. Genevieve	Ste. Genevieve	

the Chester district, Missouri and Illinois.

The name Ohara is not revived for this unit because it is more than 40 years since Ohara has been used with its original meaning. During much of this period it has been used in the fluorspar district in a restricted sense, equivalent to the Levias. Moreover, the term Ohara has a widespread and continuing use in the subsurface for an older unit, the Karnak.

The West Baden Group or Sandstone Group consists of the Bethel, Ridenhower, and Cypress Formations or their equivalents in Indiana and eastern Illinois where

the Ridenhower is quite sandy or shaly. There is a belt about 20 miles wide lying largely in western Indiana but including parts of White, Gallatin, and Hardin Counties, Illinois, and Union and Crittenden Counties, Kentucky, where the entire section between the Downeys Bluff and Beech Creek Limestone is essentially sandstone and is difficult to subdivide. In this area the West Baden will be most useful.

The Golconda Group comprises the Beech Creek, Fraileys, and Haney Formations in much of central and eastern Illi-

ILLINOIS STANDARD SECTION		ENGLE- MANN 1863	S. WELLER 1920a	ULRICH 1922	LAMAR 1925	S. WELLER & KREY, '39 J.WELLER, '39 STOPS 15-17	J.M.WELLER & EKBLAW 1940	SWANN 1956	THIS PAPER									
Grove Church	Chester Equivalent to Ferruginous Sandstone and C. Equivalent to Chesterian	1		Kinkaid	Kinkaid	Kinkaid	Kinkaid	Kinkaid	Grove Church									
Kinkaid									Kinkaid									
Gareville									Gareville									
Cave Hill									Cave Hill									
Negli Creek									Negli Creek									
Degania		2		Degania	Degania	Degania	Degania	Degonia										
Clare				Clare	Clare	Clare	Clare	Clare										
Ford Station								Ford Station										
Tygett								Tygett										
Cora				Clare	Clare	Clare	Clare	Cora										
Palistine				Palistine	Palistine	Palistine	Palistine	Palistine										
Menard		3		Menard	Menard	Menard	Menard	Menard	Menard	Allard								
Allard															Scattsburg			
Scattsburg															Walche			
Walche																		
Waltersburg	4	Waltersbg.		Walt.	Waltersburg	Waltersburg	Waltersburg	Waltersburg										
Vienna		Vienna		Vienna	Vienna	Vienna	Vienna											
Tar Springs		Tar Springs		Tar Springs	Tar Springs	Tar Springs	Tar Springs											
Glen Dean		Glen Dean		Glen Dean	Glen Dean	Glen Dean	Glen Dean											
Hardinsburg		Hardinsburg		Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg											
Haney	7	Golconda		Golconda	Galconda	Galconda	Golconda	Golconda	Haney									
Froileys													Fraileys					
Beech Creek													Beech Creek					
Cypress									8 Cyp.	Cypress	Cypress	Cypress	Cypress	Cypress				
Ridenhauer									9	Paint Creek	Upper Paint Creek XI	Paint Creek	Paint Creek	Paint Creek - Renault	Ridenhauer "Paint Creek"	Ridenhauer		
Bethel	10	Bethel		Bethel	Bethel	Bethel												
Downeys Bluff	D. or St. Louis	Renault		Lower Paint Creek IX	Renault	Renault	Downeys Bluff											
Yankeetown							Yankeetown											
Renault							Renault (Shetlerville)	Renault										
Shetlerville							Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Aux Vases				
Levias															VI	Pugnoides V	Swan Creek IV	Up. & L. Ohara III, IIa
Vases	Fredania																	
Joppa		Fredania																
Karnak				Fredania														
Spar Mt.					Fredania													
Fredania						Fredania												

FIG. 17—Development of classification in the Anna district, Illinois.

nois where there is little or no sandstone in the Fraileys but where the Hardinsburg Sandstone above the group is well developed. In this region Golconda is a limestone-shale unit between the Cypress and Hardinsburg Sandstones.

These are the only groups now formally recognized in Illinois, although other groups have been recognized in the past and there are several combinations of units that are most effectively grouped together for special purposes or in specific areas. The term Baldwin has been applied to the Tar Springs, Vienna, and Waltersburg in the Chester district. Chester has been used as a subdivision in classifications in which

Kaskaskia was used as approximately equivalent to the present Chesterian. Conversely, Kaskaskia has been used as a subdivision where Chester or Chesterian was used for the larger unit. Tribune and Birdsville have been used for lower and upper divisions of the Chesterian, but with varying boundaries. In parts of central or west-central Illinois, the Renault is largely used with some shale and very little limestone, and the Aux Vases, Renault, and Yankeetown act as a single effective reservoir. In many areas, particularly toward the northern edge of the basin, the limestones in the Clore are so poorly developed that the section between the Menard and Kinkaid is

ILLINOIS STANDARD SECTION	ULRICH 1905	BROKAW 1916	BUTTS 1917	ULRICH 1917	S. WELLER 1920b	S. WELLER 1920a	SUTTON & J.M.WELLER 1932	TIPPIE 1944, 1945	ATHERTON 1948	S. WELLER & SUTTON 1951	J.M. WELLER et al. 1952	McFARLAN et al. 1955	THIS PAPER
Grove Church													
Kinkaid													
Goreville													
Cave Hill													
Negli Creek													
Degonia													
Ford Station													
Tygett													
Coro													
Palestine													
Menard													
Allord													
Scottsburg													
Wolche													
Waltersburg													
Vienna													
Tar Springs													
Glen Dean													
Hordinsburg													
Haney													
Fraileys													
Beech Creek													
Cypress													
Ridenhower													
Sample													
Beaver Bend													
Bethel													
Downeys Bluff													
Yankeetown													
Renault													
Shetlerville													
Levias													
Vases													
Joppa													
Kornak													
Spar Mt.													
Fredonia													

FIG. 18—Development of classification in the fluorspar district, Illinois and Kentucky.

ILLINOIS STANDARD SECTION	NORWOOD 1876	FOERSTE 1910 Section at Stephensport	BUTTS 1917	MALOTT 1919	CUMINGS 1922	MALOTT 1925	SUTTON & WELLER 1932	STOUDER 1938	MALOTT et al. 1940, 1948	MALOTT et al. 1952	McFARLAN et al. 1955	GRAY et al. 1960																								
Grove Church	Leitch- field	Section at Stephensport	<i>Girvanella</i> Wallow <i>Spir. incr.</i> <i>Composita</i> etc. 5' ls.	Malott 1919	Cumings 1922	Malott 1925	Sutton & Weller 1932	Stouder 1938	Malott et al. 1940, 1948	McFarlan et al. 1955	Blue River	Paoli																								
Kinkaid													Degonia	Clore	Polestine	Menard	Waltersburg	Vienno	Tar Springs	Glen Deon	Hardinsburg	Honey	Hardinsburg	Hardsinsburg	Galcanda	Big Clifty	Beech Cr.	Elwren	Reelsville	Sample	Beaver Bd.	Bethel				
Gareville																																				
Cave Hill																																				
Negli Creek																																				
Fard Station													Waltersburg	Tor Springs	Siberia	Wickcliff	Tor Springs	Glen Deon	Hardinsburg	Golcondo	Cypress	Beech Cr.	Elwren	Reelsville	Sample	Beaver Bd.	Mooretown	Paoli	Aux Voses	Bryantsville	Levias	Rosiclore	Fre- donia	Last R.	Ste. Genevieve	Ste. Genevieve
Tygett																																				
Cora																																				
Polestine																																				
Allard													Waltersburg	Tor Springs	Siberia	Wickcliff	Tor Springs	Glen Deon	Hardinsburg	Golcondo	Cypress	Beech Cr.	Elwren	Reelsville	Sample	Beaver Bd.	Mooretown	Paoli	Aux Voses	Bryantsville	Levias	Rosiclore	Fre- donia	Last R.	Ste. Genevieve	Ste. Genevieve
Scottsburg																																				
Walche																																				
Vienna																																				
Tar Springs	Leitch- field	Section at Stephensport	Glen Deon	Hardinsbg.	Golcondo	Indian Spr. Cypress	Beech Cr.	Elwren	Reelsville	Sample	Beaver Bd.	Mooretown	Paoli	West Baden	Mitchell	Ste. Genevieve	Fredonio	St. Louis	Last R	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve												
Glen Deon																																				
Hardinsburg																																				
Haney																																				
Fraileys	Big Clifty	Garfield	Cypress	Beech Cr.	Elwren	Reelsville	Brondy Run	Beaver Bd.	Sample	Paoli	West Baden	Mitchell	Ste. Genevieve	Fredonio	St. Louis	Last R	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve												
Beech Creek																																				
Cypress																																				
Riden- hower																																				
Reelsville	Big Clifty	Garfield	red & green shale	<i>Prod. infl.</i>	Beech Cr.	Elwren	Reelsville	Brondy Run	Beaver Bd.	Sample	Paoli	West Baden	Mitchell	Ste. Genevieve	Fredonio	St. Louis	Last R	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve												
Sample																																				
Beaver Bend																																				
Bethel																																				
Downeys Bluff	Big Clifty	Garfield	Gaspere	<i>Talar.</i> sh.	Beech Cr.	Elwren	Reelsville	Brondy Run	Beaver Bd.	Sample	Paoli	West Baden	Mitchell	Ste. Genevieve	Fredonio	St. Louis	Last R	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve												
Yankeetown																																				
Ren- oult																																				
Shetlerville																																				
Levias	Big Clifty	Ohara	congl.	silic. ool.	Paoli	West Baden	Fredonio	Ste. Genevieve	Levias	Bryantsville	Aux Voses	Paoli	Mooretown	Beaver Bend	Sample	Reelsville	Elwren	Beech Cr.	Cypress	Golconda	Honey	Hardinsburg	Hardsinsburg	Glen Dean	Tar Springs	Leitch- field	NORWOOD 1876	ILLINOIS STANDARD SECTION								
Aux Vases																																				
Jappa																																				
Karnak																																				
Spar Mt.	Big Clifty	Ohara	congl.	silic. ool.	Paoli	West Baden	Fredonio	Ste. Genevieve	Levias	Bryantsville	Aux Voses	Paoli	Mooretown	Beaver Bend	Sample	Reelsville	Elwren	Beech Cr.	Cypress	Golconda	Honey	Hardinsburg	Hardsinsburg	Glen Dean	Tar Springs	Leitch- field	NORWOOD 1876	ILLINOIS STANDARD SECTION								
Fredania																																				

FIG. 20—Development of classification in Indiana and the Stephenson district, Kentucky.

ILLINOIS STANDARD SECTION	BELL 1927 SANDOVAL	ROOT 1928 AVA	KOCH & FARLEE 1939 CENTRALIA	SLOAN & RANDALL 1939 LOUDEN	ARNOLD 1939 SALEM	WORKMAN 1940 S. ILL.	FOLK & SWANN 1946 KING	SWANN & ATHERTON 1948 SW. ILL.	BROWNFIELD 1954 CENTRALIA	SWANN 1956 SW. ILL.	SMOOT 1958 PATOKA	THIS PAPER
Grove Church												Grove Church
Kinkaid		Kinkaid				Kinkaid	Kinkaid			Kinkaid		Kinkaid
Degonia		Degonia				Degonia	Degonia			Degonia		Degonia
Clore		Clore				Clore	Clore			Clore		Clore
Palestine		Palestine				Palestine	Palestine			Palestine		Palestine
Menard		Menard		Menard	Menard	Menard	Menard			Menard		Menard
Waltersburg			Waltersburg	Waltersburg	Waltersburg	Waltersburg	Waltersburg			Waltersburg		Waltersburg
Vienna		Vienna	Vienna	Vienna	Vienna	Vienna	Vienna			Vienna		Vienna
Tar Springs		Tar Springs	Tar Springs	Tar Springs	Tar Springs	Tar Springs	Tar Springs			Tar Springs		Tar Springs
Glen Dean		Glen Dean	Glen Dean	Glen Dean	Glen Dean	Glen Dean	Glen Dean			Glen Dean		Glen Dean
Hardinsburg		Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg			Hardinsburg		Hardinsburg
Haney						1 Golconda						Haney
Frailays						2 Golconda						Frailays
Beech Creek						3 Golconda						Beech Cr.
Cypress	Stein	Cypress	Cypress	Cyp. Weiler	Cypress	4 Cypress						Cypress
Ridenhower		Paint Creek	Paint Creek	Paint Creek	Paint Creek	Paint Creek	Paint Creek	Upper Paint Creek ls. & sh.	Paint Creek	Upper Paint Creek	Paint Creek	Ridenhower
Bethel						Bethel	Bethel	Paint Cr. ss.	Paint Creek	Paint Cr. sd.	Bethel	Bethel
Downeys Bluff							pk. crin.	L. Paint Cr. ls. (pink crinoidal)	Low. Paint Cr.	Low. Paint Cr.	Downeys Bl.	Downeys Bl.
Yankeetown	Benoist	Yankeetown	Bethel (Ben.)	Bethel (Ben.)	Bethel (Ben.)	Beth.	Benoist	Benoist	Yankeetown (Benoist)	Benoist	Yankeetown	Yankeetown
Renault		Renault	Renault	Renault	Renault	Renault	Renault	Renault	Renault	Renault	Renault	Renault
Aux Vases		Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases	Aux Vases
Jappa			L. Ohara		L. Ohara	Levios	Levios	Lev. (L. Oh.)				Karnak
Karnak			Rosiclar		Rosiclar	Rosiclar	Rosiclar	Rosiclar				Ste. Spar Mt.
Ste. Genevieve		Ste. Genevieve	Fredonia	Genevieve	Fre-donia	Fredonia	Fredonia	Fredonia	Ste. Genevieve	Fredonia	Ste. Genevieve	Fredonia

FIG. 21—Subsurface correlations in western Illinois.

most readily treated as a single sandstone-shale unit. Such combined units as these last two can be treated informally by using such hyphenated terms as Aux Vases–Yankeetown Sandstones or Palestine–Degonia Formations.

Several other groups are used in Indiana or Kentucky. The Paoli Limestone is considered a formation although it is equivalent to the Downeys Bluff and Yankeetown Formations plus the Shetlerville Member of the Renault. The Blue River Group consists of the St. Louis, Ste. Genevieve, and Paoli Limestones. The Stephenson Group as now used in Indiana is exactly equivalent to the Okaw Group of Illinois. The Gasper (Girkin) Limestone or Group includes the units from the base of the Shetlerville to the top of the Beech Creek in areas where these units are largely or entirely limestone. The Litchfield Shale or Group is now treated as though nominally equivalent to all the Elviran formations, although it actually is used in places where only the lower three or four of these formations are present. Buffalo Wallow has been used for the interval from the base of the Vienna through the Kinkaid.

MEGAGROUPS

Swann and Willman (1961) proposed the Pope Megagroup to include the sequence of alternating sandstone-dominated and limestone-dominated units of late Valmeyeran and Chesterian age that overlie the main succession of limestones of Mississippian age. They applied the name Mammoth Cave Limestone Megagroup to the latter succession. The boundary between these two megagroups is placed in any region at the base of the lowest prominent sandstone unit. At the edge of one such unit the boundary is offset to the base of the next one. It generally rises to the south or east from a position within strata equivalent to the St. Louis Limestone in Iowa to the top of the Glen Dean, or perhaps higher, in eastern Tennessee. In the Illinois Basin the boundary ranges from the top of the St. Louis Limestone in the northwest to the top of the Beech Creek Lime-

stone at the southeast. The bulk of the Mammoth Cave Limestone Megagroup is composed of formations older than those considered here. The top of the Pope Megagroup is placed at the top of the Chesterian.

BIOSTRATIGRAPHY

Biostratigraphic zones are units of rock differentiated because of the kind or kinds of fossils they contain, the fossils being considered as biological entities rather than as rock-forming constituents. There is disagreement as to the precise nature of biostratigraphic zones, because different concepts have been uppermost in the minds of those who have created and used them.

Zones may be classified as 1) range zones, based on the known range of distribution of a single biologic entity or taxon; 2) peak zones, based on the abundance of a single taxon; and 3) assemblage zones, based on the occurrence of a number of taxa rather than of a single one.

This classification is being used for newly described zones but is difficult to apply to some zones that have been used in the past with different shades of meaning. Certain zones first used as range zones were changed with further use into one of the other types. Extensions in the range of a zonal fossil give a choice of extending the zone to the additional beds or retaining the zonal name for the original beds by changing the classification of the zone. Butts (1929) believed the coral he called *Campophyllum gasperense* was confined to the Beaver Bend Limestone Member of the present paper and he used the term "*Campophyllum gasperense* Zone" for this member. Subsequent discovery of this coral in an older unit, the Downeys Bluff Limestone, is recorded in later literature (Sutton and J. M. Weller, 1932; McFarlan et al., 1955) in which Butts' zone has a dual usage. It appears in some contexts as a peak zone equivalent to the Beaver Bend and in others as a range zone expanded to include the Downeys Bluff. The distinction between these two meanings is made obvious in each instance in these particular publications

ILLINOIS STANDARD SECTION	BLATCH- LEY 1913 LAWRENCE	WASSON 1938 CLAY CITY	LEE 1939 CLAY CITY	COHEE 1942 NEW HARMONY	INGHAM 1948 POWELL'S LAKE	ATHERTON 1948 SE. ILL.	SWANN & ATHERTON 1948 WABASH VAL.	SWANN & ATHERTON 1948 WESTERN KY.	BYBEE 1948 HITESVILLE	SWANN 1951 WABASH VAL.
Grave Church										
Kinkaid		Zone 4	Kinkaid	Kinkaid	Kinkaid	Kinkaid		Kin- kaid		Kinkaid
Gareville					Upper					
Cave Hill								Lower		
Negli Creek		Zone 5		Kinkaid	Lower					
Degania			Degania	Degania	Degania	Degania		Degania		Degania
Fard Station			Clare	Clare	Clare	Clare		Clare		Clare
Tygett						Clare sd				Clare sd
Cara										
Palestine			Palestine	Palestine	Palestine	Palestine		Palestine		Palestine
Allard										
Menard		Zone 6	Menard	Menard	Menard	Menard		Menard	Menard	Menard
Scattsburg					Massive M	Massive M				
Walche					Little M.	Little M.		Little M		
Waltersburg			Waltersburg	Waltersburg	Waltersburg	Waltersburg		Waltersburg	Waltersburg	Waltersburg
Vienna			Vienna	Vienna	Vienna			Vienna	Vienna	Vienna
Tar Springs			Tar Springs	Tar Springs	Tar Springs			Tar Springs	Tar Springs	Tar Springs
Glen Dean		Zone 7	Glen Dean	Glen Dean	Glen Dean		Glen Dean	Glen Dean	Glen Dean	Glen Dean
Hardinsburg			Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg
Haney					Upper					
Fraileys	Gas		Galcanda	Galcanda	Galcanda	Galcanda	Galcanda	Galcanda	Galcanda	Galcanda
Beech Creek		Zone 8	Basal G.	Basal G.	Barlaw	Barlaw	Barlaw	Barlaw	Barlaw	Barlaw
Cypress	Kirkwood	Weiler	Weiler	Cypress	Cypress	Cypress	Cypress	Cypress	Cypress	Cypress
Riden- hauer			Cypress	Paint Creek	Paint Creek		Upper Pt.Cr. Pt Cr. ss Pt Cr. ls	Upper Pt.Cr ls. Paint Cr. ss. Lower Pt.Cr ls		Up Pt.Cr.s
Bethel	Tracey			Bethel	Bethel		Bethel (Ben.)	Bethel	Bethel	Bethel-Ben.
Dawneys Bluff			Paint Creek	Renault	Renault		Up. Ren. Ren. sh & ss	Renault ls. Shale	Renault	Dawn. Bl. Renault- Benolst
Yankeetown			Bethel				Lower Renault	Aux Vases ls.	Aux Vases ls. or L. Renault	Basin Renault Shettlerv. Levias
Ren- ault		Zone 9	Renault	Aux Vases limestone	Aux Vases ls. or Lower Renault					
Shettlerville										
Levias										
Aux Vases		Bradley	Aux Vases	Aux Vases	Aux Vases		Aux Vases	Aux Vases	Aux Vases	Rasiclare-Basin Aux Vases
Jappa							Levias (Low Ohara)			
Karnak			L. Ohara				Rasiclare			
Ste. Spar Mt.		Zone 10	Fre- donia	Ste. Genevieve	Ste. Genevieve		Fredania	Ste. Genevieve		Basin Ste. Genevieve
Gene- vieve	McCluskey	McCl.	McCl.							

Fig. 22—Subsurface correlations in

but would not be clear in a casual reference.

Many of the widely quoted classic zones in the geological literature were originally based on the occurrence of a single species. They later were carried far beyond the geographic and ecologic limits of that species by means of other fossils known to occur with it or believed contemporaneous with it. Thus these zones have evolved from range zones to assemblage zones.

The *Prismopora serrulata* Zone is one that has been used with many different meanings. The occurrence of this distinctive bryozoan as a conspicuous element in the fauna of the Glen Dean Limestone has been noted for more than 75 years. It also is abundant at some localities in the Haney Limestone and in the Cave Hill Member of the Kinkaid Limestone, is less common in

the Vienna Limestone, and has been found in the Fraileys and Clore Formations. Its range, as known at present, corresponds in essence to that of the clam *Sulcatopinna missouriensis* which also has been found from the Fraileys to the Kinkaid, but the two forms occur in quite different types of limestone and therefore reach peaks of abundance in different formations. The literature shows the *Prismopora serrulata* Zone has been used as a range zone equivalent to the Glen Dean Limestone, a range zone equivalent to the section from Golconda (Haney?) through Vienna, a peak zone equivalent to the Glen Dean, a peak zone equivalent to the Glen Dean and Golconda, an assemblage zone equivalent to the Glen Dean, and an assemblage zone (concurrent-range zone) equivalent to the Vienna as characterized by the overlap in

WALKER et al. 1951 HENDERSON QUAD.	BOWEN 1952 GUFFIE		CATHEY 1955 WOOD 1955 NEWBURGH MORGANFIELD S	FUGATE 1956 SMITH MILLS NORTH	SWANN 1956 WABASH VALLEY	WHITING 1959 COOKS MILLS	THIS PAPER
							Grove Church
	Kinkaid	Upper			Kinkaid		Kinkaid
Top of Chester or Chester lm.	Kinkaid	Lower	Chester lime	Kinkaid	Lower		Kinkaid
	Degonia		Degonia	Degonia	Degonia	Degonia	Degonia
	Clore		Clore	Clore	Clore	Clore	Clore
Chester or stray			Clare	Clare ls.			Clare
	Palestine		Palestine	Palestine	Palestine	Palestine	Palestine
	Menard	Upper	Menard	Upper	Menard	Menard	Menard
	Menard	Massive	Menard	Middle or massive	Menard	Menard	Menard
	Menard	Lower or little	Menard	Lower or little	Menard	Menard	Menard
Chapman Fuqua sand	Waltersburg	Big mud	Waltersburg	Waltersburg	Waltersburg	Waltersburg	Waltersburg
Brown lime	Vienna	1 st Brown lime	Vienna	Vienna	Vienna	Vienna	Vienna
Jett sand	Tar Springs	Jett sand	Tar Springs	Tar Springs	Tar Springs	Tar Springs	Tar Springs
Little lime	Glen Dean	2 nd Brown lime 2 nd Jett sand Little lime	Glen Dean	Glen Dean	Glen Dean	Glen Dean	Glen Dean
Jones sand	Hardinsburg	Jones sand	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg	Hardinsburg
Big lime	Galconda	Big lime	Galconda	Galconda	Galconda	Galconda	Galconda
	Galconda	Jackson	Jackson	Jackson (Big Clifty)	Galconda	Galconda	Galconda
	Galconda	Barlow	Barlow	Barlow	Galconda	Galconda	Galconda
Barlow sand	Cypress	Barlow sd.	Cypress	Cypress	Cypress	Cypress	Cypress
	Upper Pt. Cr.	Bethel lime	Paint Creek	Upper Is.	Paint Creek	Paint Creek	Paint Creek
	Paint Cr. sd.	Bethel	Bethel	Pt. Cr. sd.	Paint Creek	Paint Creek	Paint Creek
	Lower Pt. Cr.	Cunningham lime	Upper	Lower Is.	Bethel	Bethel (P.C. sd.)	Bethel
	Bethel	Cunningham sd.	R. sand	Bethel (Benoist)	Bethel	Bethel	Bethel
	Renault	Renault	Lower	Upper	Renault	Renault	Renault
	Renault	Renault	Aux Voses	Shale	Renault	Renault	Renault
	Renault	Renault	Ste.	Lower	Renault	Renault	Renault
	Aux Voses	Aux Voses	Aux Voses	Aux Voses	Aux Voses	Aux Voses	Aux Voses
	A. V. lm.	A. V. lm.	A. V. lm.	A. V. lm.	A. V. lm.	A. V. lm.	A. V. lm.
	"L. Ohara"	"L. Ohara"	"L. Ohara"	"L. Ohara"	"L. Ohara"	"L. Ohara"	"L. Ohara"
	"Rosicl."	"Rosicl."	"Rosicl."	"Rosicl."	"Rosicl."	"Rosicl."	"Rosicl."
	McClas.	McClas.	McClas.	McClas.	McClas.	McClas.	McClas.

eastern Illinois and adjacent Kentucky.

the then-known ranges of *Prismopora serrulata* and *Sulcatopinna missouriensis*. In addition, *P. serrulata* has been noted as an important constituent in the assemblage of the *Pterotocrinus acutus*-*Pterotocrinus bifurcatus* Assemblage Zone. If it were used today, the *Prismopora serrulata* Range Zone would extend from the Fraileys to the Kinkaid. Three *Prismopora serrulata* Peak Zones would be recognized, a minor lower one equivalent to the middle or upper part of the Haney, a major middle one equivalent to the upper part of the Glen Dean, and a minor upper one equivalent to the lower part of the Cave Hill Member of the Kinkaid. It would be possible to define many different units as a *Prismopora serrulata* Assemblage Zone, but one defined on an overlap of *Prismopora* and *Sulcatopinna*

would extend from the Fraileys to the Kinkaid.

Zones based on fossils whose ancestors and descendants occur in the adjacent strata differ from those whose ancestors and descendants do not occur in these rocks. Organic evolution is the primary control on vertical distribution in the first type, but environment may be more important in the second. Examples of the first type are conodont assemblage zones and range zones based on different species of *Pterotocrinus*. These tend to be relatively stable and to have geochronological significance.

The *Prismopora* and *Sulcatopinna* Zones are examples of the second type. They may provide useful indicators of local position in the section, but they must be used with caution, particularly when applied other

ILLINOIS STANDARD SECTION	JILLSON 1930 WESTERN KENTUCKY	RUSSELL 1932 WESTERN KENTUCKY	JONES & FREEMAN 1938 BIRK CITY	WESLEY 1936 LIVERMORE	BRUCE 1949 UTICA	JACOBSEN 1950 ISLAND AREA
Grove Church						
Kinkoid						
Degonia						
Clores						
Palestine						
Menard						
Waltersburg						
Vienna						
Tar Springs						
Glen Deon						
Hordinsburg						
Haney						
Fraileys						
Beech Creek						
Cypress						
Ridenhower						
Bethel						
Downeys Bluff						
Yankeetown						
Renault						
Aux Vases						
Joppa						
Karnok						
Spor Mt.						
Genevieve						
Fredonia						

FIG. 23—Subsurface correlations in west-central Kentucky.

than locally. More than 95 percent of the specimens of *Prismopora* collected or seen in the Illinois Basin have come from the upper part of the Glen Dean, and an equally high proportion of specimens of *Sulcatopinna* from the Menard. In the absence of other data it is only prudent to map an outcrop with *Prismopora* in this basin as Glen Dean, and one with *Sulcatopinna* as Menard. It is far from prudent to correlate a limestone in another region with the Glen Dean because each contains *Prismopora*.

Goniatites provide the major zonation of equivalent strata in Europe, where corals also are widely used. Goniatites have not been found in these rocks in the Illinois Basin and most corals are so rare that their distribution seems controlled by environment rather than evolutionary stage.

The rate of evolution was only moderately rapid in most invertebrate groups. It was relatively fast in some of the echinoderms, but the most useful forms, *Agassizocrinus*, *Pterotocrinus*, *Talarocrinus*, and *Pentremites* were essentially confined to eastern North America. Because the most helpful biological zonation is provincial, it seems likely that the time-stratigraphic stages, whose identification in essence is controlled by the biostratigraphic zones, also will be of use chiefly in North America.

Evolution in the conodonts was perhaps not as fast as during late Devonian and early Mississippian time. Nevertheless, the Chesterian conodont assemblage zones based on detailed work by Rexroad and named by Collinson, Scott, and Rexroad (1962) provide closer control than is given by any other fossil group except perhaps the echinoderms. The worldwide distribution and relative freedom from environmental controls shown by many conodont species suggest that this conodont zonation can be used for interregional and intercontinental correlation. Moreover, Rexroad has given more precise information about the actual distribution of the conodonts in the Chesterian of the Illinois Basin than is available for any other group of fossils.

Much effective biostratigraphical work is done without the use of formal zones. The distribution of fossils is described in terms of specific outcrops or subsurface sections or in terms of rock-stratigraphic units. Correlations and inferences on past environment are then made directly from records of where the fossils were found. The biostratigraphic zone is a helpful device for recording and summarizing information on the distribution of fossils, used freely by some authors and rarely or never by others. Zones have been erected for certain groups of fossils but not for others of equal stratigraphic value.

GLOSSARY

Names in the official rock-stratigraphic and time-stratigraphic classifications of the Illinois Geological Survey are in capital letters. Formal names other than those in Survey classifications have only initial capitals. Only the proper nouns in informal terms are capitalized.

Alternative lithologic designations that apply in different parts of the region are given for many rock-stratigraphic units. In general, only one of these alternatives should be used in any one report. Should the purpose or area covered in a report make the choice of a single lithologic term seem inappropriate, the rank term should be used instead.

Biostratigraphic units described in the literature are included. The listing of biostratigraphic zones probably is not exhaustive, for there is no index of fossil zones available.

ABSAROKA "SEQUENCE"

A major unconformity-bounded unit that now consists of Pennsylvanian and younger strata (Sloss, 1959) but originally included Chesterian rocks. Named by Sloss, Krumbein, and Dapples (1949) for the Absaroka Mountains, Wyoming.

Agassizocrinus

A crinoid genus ranging throughout the Chesterian into the Pennsylvanian. Complete calices are uncommon, but the fused infrabasals form a solid button, rounded below but with a five-faceted pyramid above, which is quite common in many crinoidal Chesterian limestones. A single small flat button has been found in the Shetlerville; several similar specimens have been found on the upper surface of the Downeys Bluff. This form is fairly common in the upper part of the Beaver Bend. A much more robust species (see *A. cf. laevis* Peak Zone) first appears and is abundant in the Reelsville. This or a similar form ranges upward into the Glen Dean in lesser numbers. The genus remains fairly abundant throughout the Chesterian. Later species tend to be more slender than the species with broad flat bases that characterize earlier beds. Further study of this genus would provide a useful tool for zoning much of the Chesterian.

Agassizocrinus cf. laevis Peak Zone

A zone characterized by the abundance as well as the first appearance of a heavy species of *Agassizocrinus*; equivalent to the Reelsville Limestone; formalized by McFarlan et al. (1955).

ALLARD LIMESTONE MEMBER

Name proposed in this report for the upper of the three main limestone members of the Menard Formation of Elviran age; separated from the middle or Scottsburg Limestone Member by 15 to 30 feet of shale that commonly contains thin limestones; overlain either by the Palestine Sandstone or by up to 35 feet of partly fossiliferous shale with thin beds of limestone or dolomite that is also assigned to the Menard. Named for an exposure (fig. 9) of 32 feet of limestone with only minor shale interruptions directly overlain by Palestine Sandstone in the upper part of the cut at the south end of a tunnel on the Illinois Central Railroad about 2.2 miles southwest of Allard College school, in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 13 S., R. 4 E., Brownfield Quad., Johnson Co., Ill. (fig. 3, loc. 32).

Allendale sand

Drillers term with very limited usage, apparently for Cypress Sandstone in Wabash County, Illinois.

Apatognathus? *geminus*—*Cavusgnathus*
Assemblage Zone

A conodont zone corresponding to the upper part of the St. Louis Limestone but including beds now placed in the Ste. Genevieve Limestone in some areas, defined by Collinson, Scott, and Rexroad (1962).

***Archimedes* limestone**

Term applied in several early reports to the Beech Creek through the Menard (upper or first *Archimedes* limestone), to the Ste. Genevieve (middle or second *Archimedes* limestone), and to the Warsaw or Warsaw-Keokuk (lower or third *Archimedes* limestone). The corkscrew-like axes of this bryozoan are common in many shaly limestones and fossiliferous shales in the Chesterian. Many species have been described, and some have been considered diagnostic of certain stratigraphic units, but little information on precise ranges is available. The genus reaches a peak both in numbers of species and abundance of specimens in the Haney and Fraileys Formations.

Aux Vases lime

Subsurface term that has had at least three related uses: 1) largely in the late 1940's in the deep basin counties of Indiana and Kentucky for the Levias or the Levias and Shetlerville Members of the Renault overlying the Aux Vases Sandstone; 2) in the 1950's in the deep basin in Illinois for the Joppa Limestone Member underlying the Aux Vases Sandstone; 3) in Indiana east of the deep basin for dolomite or limestone approximately equivalent in age and position to the Aux Vases Sandstone.

AUX VASES SANDSTONE or FORMATION

Sandstone and siltstone, with minor shale, dolomite, and limestone, largely of late Genevievian age, overlying the Ste. Genevieve Limestone and underlying the Renault Formation, which locally has at its base the Levias Limestone Member. This definition leaves unaltered the Aux Vases commonly recognized in outcrop in the Chester district of Missouri and Illinois and

in the subsurface throughout the Illinois Basin. It transfers the Rosiclare Sandstone Member of the fluorspar district and part of the Hoffner Member of outcrops in the Anna district from the Ste. Genevieve to the Aux Vases. Named by Keyes (1892) for outcrops midway between St. Marys and Ste. Genevieve in the bluffs at the mouth of the Aux Vases River, N $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 13, T. 37 N., R. 9 E., extended, Chester Quad., Ste. Genevieve Co., Mo. (fig. 3, loc. 12).

Baldwin Formation or Group

Name formerly used for the Waltersburg, Vienna, and Tar Springs Formations in the Chester district. Although proposed as a replacement for the Upper Okaw of Stuart Weller, it differs by including the Waltersburg, which was placed in the Menard rather than the Okaw in Stuart Weller's original work. Named by Weller and Weller (1939) for good exposure south of the town of Baldwin, sec. 14, T. 4 S., R. 7 W., Baldwin Quad., Randolph Co., Ill. (fig. 3, loc. 7).

Barker sand

Drillers term for the Cypress Sandstone in Indiana.

Barlow lime

Subsurface term, widely and accurately applied throughout the basin to the Beech Creek Limestone.

Barlow sand

Drillers term for Cypress Sandstone in the Owensboro district, Kentucky.

***Batostomella nitidula* Peak Zone**

Zone defined by S. Weller (1926), in the Cora Member of the Clore Formation, characterized by limestone surfaces covered with a delicate branching bryozoan which occurs in lesser numbers in other formations.

BEAVER BEND LIMESTONE

MEMBER or SHALE MEMBER

Limestone and shale of Gasperian age forming the lower member of the Ridenhower Formation in Illinois; given formational rank in Indiana and Kentucky; over-

lies clastic rocks assigned to the Bethel Sandstone and underlies those assigned to the Sample Sandstone Member. Named by Malott (1919) for exposures near the bottom of a cut on the Baltimore and Ohio Railroad just south of U. S. Highway 50, half a mile east of Huron near a prominent bend in Beaver Creek, in the SW $\frac{1}{4}$ sec. 5, T. 3 N., R. 2 W., Huron Quad., Lawrence Co., Ind. (fig. 3, loc. 74).

BEECH CREEK LIMESTONE

Limestone of latest Gasperian age overlying the Cypress Sandstone or equivalent clastic rocks of the Elwren Formation and underlying the Big Clifty Sandstone or equivalent rocks that are at least somewhat clastic and are assigned to the Fraileys Shale. Named by Malott (1919) for a section exposed at the mouth of Ray's Cave, which is about a quarter of a mile south of Beech Creek and a quarter of a mile north of Indiana State Highway 54 at Ridgeport church, NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 13, T. 7 N., R. 4 W., Solsberry Quad., Greene Co., Ind. (fig. 3, loc. 80).

Bellair sands

Drillers term for several Pennsylvanian sandstones and for the Cypress Sandstone (Bellair 900 foot) in Crawford County, Illinois.

Benoist sand

Drillers term used 1) throughout western Illinois west of eastern Franklin, eastern Jefferson, and central Clay and Effingham Counties for the Yankeetown Sandstone; 2) in eastern Illinois and the deep basin counties of Indiana and Kentucky for the Bethel Sandstone; 3) less widely in shallow producing areas near the outcrop in Indiana and Kentucky for the Sample Sandstone.

Bethel lime

Name applied, generally as an informal drillers term, to the Reelsville Limestone in the Owensboro district, Kentucky.

Bethel sand

Term with three uses as the name of a pay sand—1) in the deep basin area gen-

erally applied to the Bethel Sandstone, although even here a few major companies have consistently used the terms Bethel and Benoist for the Yankeetown and have applied the term Paint Creek sand or Illinois Paint Creek sand to the Bethel Sandstone; 2) in western Illinois commonly applied to the Yankeetown Sandstone (Benoist); 3) in the Owensboro district, Kentucky, used consistently for the Sample Sandstone, and this practice has spread at times to the shallow producing areas in Indiana and to the deep basin area in Kentucky.

BETHEL SANDSTONE or SHALE

Sandstone and related shale of Gasperian age overlying the Downeys Bluff Limestone or equivalent limestone beds and underlying the Beaver Bend Limestone Member or other relatively calcareous or fine-grained clastic parts of the Ridenhower Formation. In southwestern Illinois, it is represented by 20 to 40 feet of shale, including a very deep red clay bed, and forms most of the lower half of the Paint Creek Group, except for a few feet of Downeys Bluff. In the central or east-central part of the basin, the Bethel is the coarsest of the Chesterian sandstones and is as much as 75 to 100 feet thick. Farther east in the Indiana and much of the Kentucky outcrop belts, it consists of 5 to 40 feet of variable shale and sandstone with a persistent coal bed or coaly streak in the upper portion. At the southeast corner of the basin, it is represented by only a few inches of fossiliferous shale or shaly limestone. Named by Butts (1917) for bluffs behind Bethel (Crittenden Springs) school $3\frac{1}{2}$ miles west of Marion, SE $\frac{1}{4}$ 17-K-17, Salem Quad., Crittenden Co., Ky. (fig. 3, loc. 41).

Biehl sand

Drillers term for a basal Pennsylvanian oil sand, which has on some occasions been erroneously assigned to the Chesterian, in and near Wabash County, Illinois.

BIG CLIFTY SANDSTONE MEMBER

Term restricted in Illinois to isolated bodies of sandstone of Hombergian age

within the Fraileys Shale. The unit has formational rank in Indiana and Kentucky and consists of sandstone and shale overlying the Beech Creek Limestone, underlying the Haney Limestone, and equivalent to the entire Fraileys Shale of Illinois. Named by Norwood (1876) for sandstone cliffs along Big Clifty Creek near the line of the Illinois Central (Louisville, Paducah, and Southwestern) Railroad which crosses the creek beside U. S. Highway 62, 2 miles southwest of the village of Big Clifty, W $\frac{1}{2}$ 20-M-40, Big Clifty Quad., Grayson Co., Ky. (fig. 3, loc. 55).

Big lime

Drillers term applied, among many other uses, to the Haney Limestone in west-central Kentucky, to the Haney plus lower beds in eastern Kentucky, and to the Ste. Genevieve and older limestone units in western Illinois.

Big mud

Drillers term for the Waltersburg Shale in the Owensboro district, Kentucky.

Birdsville Group

Abandoned name applied, somewhat elastically, to most upper and middle Chesterian formations, largely in Kentucky. Named by Ulrich *in* Buckley and Buehler (1904) for outcrops near the town of Birdsville, which is in the western part of 9-I-13, Smithland Quad., Livingston Co., Ky. (fig. 3, loc. 45).

Black oolite zone

Informal descriptive term used in the subsurface of southern Illinois for the Renault, particularly the Shetlerville Member.

Blue River Group

Group comprising the St. Louis, Ste. Genevieve, and Paoli Limestones in Indiana. Named by Gray et al. (1960) for the Blue River, which drains parts of Washington, Harrison, and Crawford Counties, where the group is particularly well exposed in quarries near Milltown, sec. 15, T. 2 S., R. 2 E., Milltown Quad., Crawford Co., Ind. (fig. 3, loc. 68).

Bowling Green stone

Trade name for light colored oolitic limestone beds in the Reelsville Limestone Member, quarried for building stone north and west of Bowling Green, in and near 24-G-37, Bowling Green North Quad., Warren Co., Ky. (fig. 3, loc. 51).

Bradley sand

Drillers term used 1) for a short period in 1937 and 1938 for the Aux Vases Sandstone in Wayne and Clay Counties, Illinois; 2) for a sandstone in the Pennington Shale of Elviran age in eastern Kentucky.

Brandy Run Sandstone

Abandoned synonym for Sample Sandstone. Named by Malott (1919) for exposures on a creek southwest of the town of Marengo, sec. 12, T. 2 S., R. 1 E., and adjacent sections, Milltown Quad., Crawford Co., Ind. (fig. 3, loc. 69).

Brewerville Sandstone

Abandoned synonym for Aux Vases Sandstone. Named by S. Weller (1913) for Brewerville Township, where the type exposures are in the Mississippi River bluffs 1 $\frac{1}{2}$ to 3 miles southeast of Prairie du Rocher, secs. 26, 35, and 36, T. 5 S., R. 9 W., extended, Renault Quad., Randolph Co., Ill. (fig. 3, loc. 10).

Bristow Sandstone

Abandoned name applied by Malott (1925) both to the Palestine Sandstone (as in his sections at Siberia and Ader's Hill) and to the Tygett Sandstone Member (as at Mt. Pleasant and Peach Hill sections). First used by Logan (1924) but formally defined by Malott (1925) for outcrops probably of Palestine Sandstone on the middle fork of Anderson Creek within the village limits of Bristow, E $\frac{1}{2}$ sec. 27, T. 4 S., R. 3 W., Bristow Quad., Perry Co., Ind. (fig. 3, loc. 66).

Brown lime

Descriptive term applied 1) in the subsurface of western Kentucky to the Vienna Limestone (often called the Jett brown lime); 2) in the same region to a limestone

bed at the top of the Glen Dean Formation (second brown lime); 3) in Illinois to the Beech Creek Limestone (dense brown lime or dense pseudo-oolitic lime).

Brown sand

Drillers term used probably for the Aux Vases Sandstone in the Tri-county field, Indiana.

BRYANTSVILLE BRECCIA BED

Brecciated limestone of latest Genevievian age, a few inches to several feet thick, lying at the top of the Levias Member. It is underlain by unbrecciated Levias, or in some localities by a shaly limestone bed that may represent the Aux Vases, and overlain by unbrecciated limestone, silty limestone, or sandy limestone assigned to the Shetlerville Member of the Renault or to the Paoli Formation. First used by Patton (1949) but formally described by Malott (1952; direct quotation by Perry and Smith (1958) is commonly available) who named it for several exposures near Bryantsville but mentioned in particular one on the north side of U. S. Highway 50 a mile west of town, NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 25, T. 4 N., R. 2 W., Bedford West Quad., Lawrence Co., Ind. (fig. 3, loc. 77).

Buchanan sand

Drillers term for a basal Pennsylvanian sand in Lawrence County, Illinois, which in some publications has been mistakenly referred to the Chesterian.

Buffalo Wallow Formation

Name applied to the section from the Vienna Limestone to the Kinkaid Limestone. Named by Butts (1917) for exposures in a cirque-like amphitheater, locally called Buffalo Wallow but unnamed on recent maps, above and on the southwest side of U. S. Highway 60, 2.3 miles along the highway west of the bridge over Clover Creek in Cloverport, SW $\frac{1}{4}$ SW $\frac{1}{4}$ 25-Q-35, Cloverport Quad., on the line between Hancock and Breckinridge Cos., Ky. (fig. 3, loc. 60).

"*Camarophoria*"=*Stenosisma explanata* Range Zone

A brachiopod zone, equivalent to strata from Fraileys Shale to the Kinkaid or perhaps the Grove Church, coinciding with the Hombergian plus Elviran and helpful in distinguishing them from the Gasperian; formalized by S. Weller (1926).

"*Campophyllum gasperense*"=*Lithodrumus veryi* Range? Zone

A zone characterized by a branching coral placed in *Caninia* by some authors, proposed by Butts (1929) as equivalent to the Beaver Bend Limestone Member but now known to include the Downeys Bluff Limestone.

Caninia—see "*Campophyllum*"

Carlyle sand

Drillers term for the Cypress Sandstone in western Illinois.

Cataract Falls Sandstone Member

Synonym of Spar Mountain Sandstone Member, used only in an abstract by Malott (1946a) and withdrawn before the resultant publication (Malott, 1946b). Named for Cataract Falls, NW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 36, T. 12 N., R. 4 W., Cataract Falls Quad., Owen Co., Ind. (fig. 3, loc. 83).

CAVE HILL SHALE MEMBER or LIMESTONE MEMBER

Name proposed in this report for the middle member of the Kinkaid Formation of Elviran age; consists of about 80 feet of shale and limestone with shale beds at its boundaries.

It lies upon a massive limestone unit, the Negli Creek Limestone Member, and beneath another, the Goreville Limestone Member. The unit is 85 to 90 feet thick near its type but is thickened to 108 feet by tectonic squeezing in its type section, which is in the synclinal axis of the drag of a large fault. Named for exposures (fig. 13) in a road ditch and slope above an abandoned quarry (in the Negli Creek Member) on the west slope of Cave Hill,

SE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 3, T. 10 S., R. 7 E., Rudement Quad., Saline Co., Ill. (fig. 3, loc. 36).

CEDAR BLUFF LIMESTONE GROUP

Name proposed in this report for the Downeys Bluff, Yankeetown, and Renault (including both Shetlerville and Levias Members) Formations in areas where these formations are dominantly limestone. It is an exact, objective synonym of Ohara. Reinstatement of Ohara in its original meaning would cause confusion because Ohara now has widespread informal use in the subsurface of the deeper part of the basin for an earlier unit, the Karnak Member of the Ste. Genevieve. Named for the quarry of the Cedar Bluff Limestone Company, formerly the Ohara quarry, S $\frac{1}{2}$ 21-H-20, Princeton East Quad., Caldwell Co., Ky. (fig. 3, loc. 48).

Chapman sand

Drillers term used in Owensboro district, Kentucky, for sandstone lenses in the upper part of the Waltersburg Formation.

Chartresan Series

Name proposed by Keyes (1933) for the St. Louis, Ste. Genevieve, and Chesterian, all of which he proposed removing from the Mississippian. Named for the old French Fort Chartres, which is actually on the Mississippi floodplain near Prairie du Rocher, Randolph County, Illinois, but which Keyes confused with Fort Gage, whose position and descriptions he gives, about 16 miles to the southeast, high on the Mississippi River bluffs overlooking the mouth of the Kaskaskia River, sec. 32, T. 6 S., R. 7 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 13).

Chester Group

Term no longer used in this form. It was employed in the single stratigraphic classification for nearly a century, during which the emphasis changed from that of a relatively local unit of definite lithologic composition that would now be considered rock-stratigraphic to a widely recognized unit with time connotations. In the latter

time-stratigraphic sense, it has evolved into the Chesterian Series; in the earlier rock-stratigraphic sense it is replaced by the Pope Megagroup. First used in the form Chester Limestone by Worthen (1860), who later emended it to Chester Group (1866).

Chester lime

Term employed as an informal drillers name with several meanings, the most important being the Negli Creek (also called Chester top lime) in western Kentucky, the Clore in parts of western Kentucky where the Negli Creek is removed, and the Okaw in western Illinois.

Chester Sandstone

Abandoned synonym for the Palestine Sandstone. Although its introduction by Swallow (1858) predates other applications of the term Chester, there are no later examples of its use.

CHESTERIAN SERIES

The uppermost of the (variously two, three, or four) divisions of the Mississippian System, including rocks contemporaneous with the section from the base of the Shetlerville Member of the Renault Formation to the top of the Grove Church Formation. It overlies rocks assigned to the Genevievian Stage of the Valmeyeran (or Meramecan or Iowa) Series and underlies the Pennsylvanian System. This definition excludes the Aux Vases Sandstone which has traditionally been considered Chesterian but which correlates with fossiliferous rocks that generally have been placed in the underlying series. First named Chester Limestone by Worthen (1860) for the town in sec. 24, T. 7 S., R. 7 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 15).

***Cladognathodus*–*Cavusgnathus navicula* Assemblage Zone**

A conodont zone equivalent to the Kin-kaid Formation defined by Collinson, Scott, and Rexroad (1962).

***Cladognathodus prima* Assemblage Zone**

A conodont zone extending from the Vienna, or possibly Tar Springs, Formation to the Clore, or possibly Degonia, Forma-

tion; defined by Collinson, Scott, and Rexroad (1962).

CLORE FORMATION OR SHALE

Variable formation of Elviran age divisible into a lower limy or shaly unit (Cora Member), a middle sandy or shaly unit (Tygett Member), and an upper limy or shaly unit (Ford Station Member) overlying the Palestine Sandstone and underlying clastic rocks of the Degonia. Because the threefold nature of the formation was not commonly recognized, outcrops of the upper and lower members were confused in some reports, the thickness assigned to the unit was too small, and the formation was frequently called the Clore Limestone. The middle or Tygett Sandstone Member includes the informal Clore sand of the subsurface. Named by S. Weller (1913) for exposures in gullies on the southwest side of the ridge extending from the Randolph County Farm, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 17, to Clore school, at the southeast corner of sec. 20, although the exposure from which Weller's thicknesses and descriptions were taken is east of this ridge, in a south-draining gully just west of a north-south gravel road in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 7 S., R. 6 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 16).

Clover Creek Limestone

Abandoned name for the Reelsville Limestone. Casual reading of the only reference (Foerste, 1910) might suggest it was Haney Limestone. However, in the only section mentioned, the type section, it is 127 feet beneath the base of the Haney, overlies the Sample (misidentified as Big Clifty) Sandstone and underlies the Cypress (lower part of the Garfield) Sandstone. Named for an exposure at the mouth of Sinking (misidentified as Clover) Creek at Stephensport, in the N $\frac{1}{2}$ 2-Q-36, Rome Quad., Breckinridge Co., Ky. (fig. 3, loc. 63).

Colvin sand

Drillers term for the Tar Springs Sandstone in Indiana.

CORA LIMESTONE MEMBER or SHALE MEMBER

Name proposed in this report for the somewhat limy lower member of the Clore Formation of Elviran age, consisting of shale and interbedded limestone with occasional sandstone lenses. The unit is generally 15 to 45 feet thick. It overlies coarser clastic rocks of the Palestine Formation and underlies those of the Tygett Sandstone Member of the Clore. The type section consists of 12 feet of partly fossiliferous shale containing interbeds an inch or so thick of dark colored, phosphatic, sandy limestone overlying a 4-inch coal bed at the top of the Palestine Sandstone and separated from an outcrop of the Ford Station Member above by a 22-foot covered interval. Named for an exposure in the bluff at the south edge of the mouth of Degonia Creek Hollow near Cora in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 16, T. 8 S., R. 5 W., Campbell Hill Quad., Jackson Co., Ill. (fig. 3, loc. 21).

Cunningham sand

Drillers term used 1) in western Kentucky for the Bethel Sandstone; 2) in restricted parts of Indiana for the Big Clifty Sandstone (Cunningham shallow sand); 3) in restricted parts of Indiana for the Sample Sandstone (Cunningham deep sand).

CYPRESS SANDSTONE or SHALE

Sandstone and associated shale of late Gasperian Age overlying limestone or relatively finer clastics assigned to the Ridenhower Formation or equivalents and underlying the Beech Creek Limestone. The synonym Elwren is used in parts of Kentucky and Indiana because of the former widespread misapplication of the name Cypress to the Big Clifty Sandstone. Named by Engelmann (1863) for massive sandstone exposures in the bluffs of Cypress Creek in the southwestern part of T. 12 S. and the northern part of T. 13 S., R. 1 E., Dongola Quad., Union Co., Ill. (fig. 3, loc. 27).

Cypress Sandstone (Indiana and Kentucky)

During the period from 1910 to about 1955, the name Cypress Sandstone was ap-

plied in Indiana and Kentucky, except in the fluorspar district and the oil fields of the deep basin, to the Big Clifty Sandstone rather than to the true Cypress, which also is called Elwren in parts of those states.

Cystodictya labiosa Zone

As formalized by S. Weller (1926), a biostratigraphic unit essentially equivalent to the Gasperian, although the branching, ribbon-like bryozoan *Cystodictya labiosa* occurs rarely in latest Genevievian rocks and has not been found in the youngest Gasperian unit, the Beech Creek. *Cystodictya* is commoner in the Ridenhower than in the lower part of the Gasperian and the zone has been used as a peak zone or assemblage zone equivalent to the Ridenhower only.

Davidson deep sand

Drillers term for the Tar Springs Sandstone in Indiana. The Davidson shallow sand is Pennsylvanian.

DEGONIA SANDSTONE or SHALE

A variable but dominantly clastic unit, ranging from 150 feet of massive sandstone in parts of western Illinois to 20 feet of calcareous shale with limestone and bedded chert in parts of Kentucky. It overlies the relatively high-carbonate Ford Station Member of the Clore and underlies the Negli Creek Limestone Member of the Kincaid. Named by S. Weller (1920a) for outcrops of massive sandstone in the bluffs of the Mississippi and small tributaries in secs. 12-16 and 21-25, T. 8 S., R. 5 W., Degonia Township, Campbell Hill Quad., Jackson Co., Ill. (fig. 3, loc. 20).

Denny sand

Drillers term reportedly used in Perry County, Illinois, apparently for Cypress Sandstone.

Diaphragmus Zone

A biostratigraphic unit, formally introduced by J. M. Weller et al. (1948) that is essentially equivalent to the Chesterian. *Diaphragmus* is present in the upper Gene-

vievian and is easily confused with other small productids.

“*Dictyoclostus*”—see “*Productus*”

DOWNEYS BLUFF LIMESTONE or FORMATION

Limestone and related rocks of Gasperian age that overlie clastic rocks of the Yankeetown Formation and underlie the Bethel Sandstone. In western Illinois the formation consists of several feet of interbedded shale and cherty limestone with silicified fossils at the base of the Paint Creek Group and commonly has been called “lower Paint Creek.” In outcrops of the fluorspar district and in the subsurface of the deep basin area, it consists of 20 to 35 feet of slightly cherty, generally nonshaly limestone at the top of the Cedar Bluff Group and commonly has been called “upper Renault.” It is equivalent to the upper nonshaly part of the Paoli Limestone of Indiana and Kentucky. Named by Atherton (1948) for an outcrop of 31 feet of limestone immediately underlying the Bethel Sandstone in the Ohio River bluff at Downeys Bluff, which is the northeastern of the two hills on the river just below Rosiclare, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 5, T. 13 S., R. 8 E., Rosiclare Quad., Hardin Co., Ill. (fig. 3, loc. 38).

ELVIRAN STAGE

Name introduced in this report in this form for the youngest of three stages of the Chesterian, overlying the Hombergian Stage, underlying the Pennsylvanian System, and comprising the Mississippian rocks younger than the Glen Dean Limestone. It is equivalent to the Elvira Group of J. M. Weller (1939), named for Elvira Township, T. 12 S., R. 2 E., Vienna, Dongola, Carbon-dale, and Marion Quads., Johnson Co., Ill. (fig. 3, loc. 26).

Elwren Sandstone

Synonym of Cypress still used in portions of Indiana and Kentucky where the name Cypress would be confusing because of its recent widespread misapplication to the Big Clifty Sandstone. Named by Malott (1919) for cuts on the Illinois Central Railroad

about a mile northeast of Elwren, now Stanford Station, near the center of sec. 20, T. 8 N., R. 2 W., Stanford Quad., Monroe Co., Ind. (fig. 3, loc. 82).

Endothyra lime

Informal name employed widely for the Salem Limestone of Valmeyeran age but also applied for a short time, from 1935 to 1937, to the Glen Dean Limestone in the deeper part of the Illinois Basin. The foraminiferal genera *Endothyra* and *Plectogyra* are common in many Mississippian limestones, and appear more abundant in the Negli Creek than in the Glen Dean.

Euphemia randolphensis fauna

A fauna including several species of small clams, snails, and endothyrid foraminifera that is characteristic of some beds in the Beech Creek Limestone (basal Okaw).

Ferruginous sandstone

Nongeographic name used until about 1900 for the Aux Vases Sandstone in the Chester area, and apparently for the Bethel and Cypress Sandstones across southern Illinois.

FORD STATION LIMESTONE MEMBER or SHALE MEMBER

Name proposed in this report for the upper member of the Clore Formation of Elviran age, consisting of interbedded shale and limestone with rare sandstone lenses. The unit is typically 20 to 50 feet thick. It overlies coarser clastic rocks of the Tygett Sandstone Member and underlies the Degonia Sandstone. The type section (fig. 12) consists of 38 feet of shale containing limestone units a few inches to five feet thick that is overlain by Degonia Sandstone and separated from the sandstones and shales of the Palestine Formation by 35 feet of poorly exposed shale assigned to the other members of the Clore. Named for an abandoned quarry east of Illinois Highway 3 about $1\frac{1}{4}$ miles southeast of the bridge over Marys River and a quarter of a mile southeast of the Ford Station siding on the Missouri Pacific Railroad, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec.

33, T. 7 S., R. 6 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 17).

FRAILEYS SHALE or FORMATION

Shale with associated limestone and sandstone of earliest Hombergian age overlies the Beech Creek Limestone and underlies the Haney Limestone. The three formations comprise the Golconda Group. The unit is not formally recognized in Indiana and Kentucky, where it is replaced by the Big Clifty Sandstone, but sandstone is less abundant in Illinois and the Big Clifty is here considered a discontinuous member of the Fraileys. Named by McFarlan et al. (1955) for an outcrop of 94 feet of shale, partly silty, with some limestone lenses, underlying the type section of the Haney Limestone in a bluff overlooking Haney Creek about a mile southwest of the abandoned Fraileys Landing and Fraileys store, NE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 9, T. 12 S., R. 10 E., Repton Quad., Hardin Co., Ill. (fig. 3, loc. 40).

FREDONIA LIMESTONE MEMBER

Limestone, largely oolitic, cross-bedded, and crinoidal, forming the lowest and thickest of several members of the Ste. Genevieve Limestone of Genevievian age. It overlies darker, more lithographic, chertier limestone assigned to the St. Louis Limestone and is restricted in this report to beds under sandstone or impure limestone assigned to the Spar Mountain Sandstone Member. This revision leaves unchanged the current concept of the Fredonia in the subsurface of the Illinois Basin, in Indiana outcrops, and in outcrops in south-central and southwestern Illinois. In these areas the Fredonia traditionally has included only beds up to the base of the Spar Mountain Member, although that unit was misidentified as Rosiclare. The revision is significant only in Hardin County, Illinois, and Livingston, Crittenden, and Caldwell Counties, Kentucky. There the Fredonia now includes only the lowest but largest of three divisions formerly placed in it. The former "middle Fredonia," or "sub-Rosiclare Sand," is the Spar Mountain Sand-

stone Member. The former "upper Fredonia" comprises the Joppa and Karnak Members. Named by Ulrich (1905) for the town of Fredonia in 14-I-18, Fredonia Quad., Caldwell Co., Ky. (fig. 3, loc. 46).

French Lick stone

Trade name formerly applied to whetstone and grinding stones cut, apparently from the Big Clifty Sandstone, in the vicinity of French Lick, sec. 3, T. 1 N., R. 2 W., Hillham and French Lick Quads., Orange Co., Ind. (fig. 3, loc. 72).

Froemling sand

Drillers term for Tar Springs Sandstone in Jackson County, Illinois.

Fuqua sand

Drillers term for sandstone lenses in the lower part of the Waltersburg Formation in west-central Kentucky.

Garfield Sandstone

Name used briefly for the Big Clifty, Cypress, and possibly Hardinsburg Sandstones. Although the Garfield was defined as lying above the Big Clifty, the latter name was erroneously applied to the Sample Sandstone wherever the Garfield was identified. Named by Foerste (1910) for outcrops near Garfield, NE $\frac{1}{4}$ 19-P-38, Garfield Quad., Breckinridge Co., Ky. (fig. 3, loc. 59).

Gas sand

Descriptive term with general use, but applied in particular to the Big Clifty Sandstone Member in and near Lawrence County, Illinois.

Gasper Oolite

Limestone, largely oolitic, comprising the section from the base of the Shetlerville Member of the Renault Formation to the top of the Beech Creek Limestone in Kentucky and states to the south and east. This was the original usage in the type region and the commonest usage everywhere, but because the term was used with other meanings (Beaver Bend through Beech Creek, Beaver Bend through Reelsville, Downeys Bluff through Beech Creek, Shetlerville

through Haney), the name Girkin was proposed as a substitute by Sutton and J. M. Weller (1932). Named by Butts (1917); type section also serves as the type for the Gasperian Stage.

GASPERIAN STAGE

Name formally proposed in this report for the oldest of three stages of the Chesterian, which overlies the Genevieve Stage of the Valmeyeran Series and underlies the Hombergian Stage of the Chesterian. It comprises rocks equivalent to those from the base of the Shetlerville Member of the Renault Formation to the top of the Beech Creek Limestone. Named for the Gasper Limestone first described by Butts (1917) whose type section overlies *Platycrinites penicillus*-bearing Ste. Genevieve Limestone and underlies the Big Clifty Sandstone in bluffs of the Gasper River, in and near the eastern half of G-35, Hadley Quad., Warren Co., Ky. (fig. 3, loc. 50).

Genevieve Group

Abandoned term suggested to include the Warsaw Shale and all younger Mississippian formations, equivalent to Chesterian plus Meramecan of modern terminology. Named by Williams (1891) for exposures in Ste. Genevieve County, Missouri.

GENEVIEVIAN STAGE

Name proposed in this report for the only stage now recognized in the Valmeyeran; it lies at the top of that series. It overlies rocks generally placed in the St. Louis Limestone and underlies the Gasperian Stage of the Chesterian Series. It includes the equivalents of the youngest *Platycrinites penicillus*-bearing beds placed in the Ste. Genevieve Limestone, which are younger than the youngest beds of this formation at its type locality. It thus includes the Aux Vases Sandstone, the Levias Limestone Member, which is now placed in the Renault, and probably some unfossiliferous beds included in the lower part of the Renault in its type region. Named for the Ste. Genevieve Limestone of Shumard (1860), the type section of which is in the Mississippi River bluff 1 to 4 miles southeast of the

town of Ste. Genevieve in the northern part of T. 37 N. and southern part of T. 38 N., R. 9 E., extended, Weingarten Quad., Ste. Genevieve Co., Mo. (fig. 3, loc. 11).

Gennet Creek Formation

Abandoned, little used synonym of Clore Formation; named by Harrell (1935), but not clearly defined. Origin of the name is not known.

Gibson sand

Drillers term for the Hardinsburg Sandstone in Indiana.

Girkin Formation or Group

Name introduced by Sutton and J. M. Weller (1932) and used as a synonym for Gasper in its most common sense, that is, for limestone strata in Kentucky and elsewhere equivalent to the section from the base of the Shetlerville to the top of the Beech Creek. This was the authors' obvious intent, but their designation, while mentioning a type section, did not describe it and was couched in terms of supposed Illinois equivalents, Renault and Paint Creek, whose upper and lower limits are actually older (Levias through Reelsville). Named for the town of Girkin, 2-G-38, Bristow Quad., Warren Co., Ky. (fig. 3, loc. 52).

GLEN DEAN LIMESTONE or FORMATION

Limestone and associated shales of Hombergian age overlying coarser clastics assigned to the Hardinsburg Sandstone and underlying those assigned to the Tar Springs Sandstone. The formation traditionally has included at the top an extremely fossiliferous shale with thin limestone stringers that is the source of most of the varied fauna attributed to the Glen Dean, but this unit recently has been transferred to the Tar Springs in some Indiana publications (Gray et al., 1960). Named by Butts (1917) for cuts along abandoned tracks of the Louisville and Nashville Railroad on either side of the town of Glen Dean in the southern part of 3-N-36 Glen Dean Quad., Breckinridge Co., Ky. (fig. 3, loc. 56).

***Gnathodus bilineatus*–*Cladognathodus mehli* Assemblage Zone**

A conodont zone equivalent to the Glen Dean Formation; proposed by Collinson, Scott, and Rexroad (1962).

***Gnathodus bilineatus*–*Cavusgnathus characta* Assemblage Zone**

A conodont zone corresponding to strata from the Ste. Genevieve through the Ridenhower or Cypress Formations; defined by Collinson, Scott, and Rexroad (1962).

***Gnathodus bilineatus*–*Cavusgnathus cristata* Assemblage Zone**

A conodont zone approximately equivalent to the Golconda Group; defined by Collinson, Scott, and Rexroad (1962).

GOLCONDA GROUP

A group of formations of Gasperian and Hombergian age that are largely limestone and shale in Illinois, comprising in ascending order the Beech Creek Limestone, Fraileys Shale, and Haney Limestone. The formational rank now given these units raises the Golconda, formerly a formation, to group rank. In most Indiana and Kentucky literature, the term Golconda has been used for only the Haney Limestone rather than for the unit comprising the Beech Creek, Fraileys (or Big Clifty), and Haney as in Illinois. First used by Brokaw (1916), but formally defined by Butts (1917) for exposures in the Ohio River bluffs above Golconda, secs. 5, 8, and 18, T. 13 S., R. 7 E., Shetlerville Quad., Pope Co., Ill. (fig. 3, loc. 35).

GOREVILLE LIMESTONE MEMBER

Name proposed in this report for the massive upper limestone member of the Kinkaid Formation of Elviran age. It is a limestone unit 15 to 45 feet thick lying upon a shale bed at the top of the somewhat shaly Cave Hill Member of the Kinkaid and beneath calcareous shale of the Grove Church Formation. The type section (fig. 14) consists of 33 feet of somewhat cherty limestone without shale interruptions that lies above an 8- or 10-foot green

and red shale bed at the top of an 85-foot section of limestone and shale of the Cave Hill Member and beneath sandstone of Pennsylvanian age. Named for exposures in the quarry of the Southern Illinois Rock and Stone Company, at Buncombe 4 miles south of Goreville, SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 10, and NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 15, T. 12 S., R. 2 E., Vienna Quad., Johnson Co., Ill. (fig. 3, loc. 25).

GROVE CHURCH SHALE or FORMATION

Name proposed in this report for shale and associated limestone of latest Elviran age, formerly considered part of the Kinkaid Formation. It overlies the massive limestone beds of the Goreville Limestone Member of the Kinkaid Formation and is unconformably overlain by Pennsylvanian sediments. It reaches a maximum thickness of 65 feet in the subsurface of northern Johnson County, Illinois, where it includes lenticular limestone layers as much as five or eight feet thick. The type section is 18 feet of fossiliferous shale with thin limestone beds that overlies 75 feet of limestone with minor shale beds and covered intervals assigned to the Kinkaid. Named for exposures in a cut along a nearly abandoned roadway and nearby gullies about 0.3 mile northwest of Cedar Grove church, along the W line NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 31, T. 11 S., R. 2 E., Carbondale Quad., Johnson Co., Ill. (fig. 3, loc. 24).

HANEY LIMESTONE

Limestone with minor amounts of associated shale, of Hombergian age, overlying predominantly clastic rocks assigned to the Fraileys Shale or the equivalent Big Clifty Sandstone and underlying clastic rocks of the Hardinsburg Sandstone. The Haney is the upper part of the unit generally considered Golconda in Illinois and the subsurface of the deep basin counties in Indiana and Kentucky, but the name Golconda in most of the Kentucky and Indiana literature refers to the Haney only. Named by McFarlan et al. (1955) for an outcrop of 30 feet of limestone near the crest of a Har-

dinsburg-capped bluff overlooking Haney Creek and overlying the type section of the Fraileys Shale, NE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 9, T. 12 S., R. 10 E., Repton Quad., Hardin Co., Ill. (fig. 3, loc. 40).

HARDINBURG SANDSTONE or SHALE

Clastic rocks of Hombergian age overlying limestone-dominated sediments assigned to the Haney Limestone and underlying those assigned to the Glen Dean Limestone. Name first used by Brokaw (1916), but formally defined by Butts (1917), for exposures in the vicinity of Hardinsburg in 13 and 18-P-37, Hardinsburg Quad., Breckinridge Co., Ky. (fig. 3, loc. 58).

Hartselle Sandstone

Sandstone and associated shale of Hombergian age in Alabama, Mississippi, and Tennessee now commonly correlated with the Hardinsburg Sandstone; mentioned frequently in discussions of correlation of units within the Illinois Basin.

Hightower sands

Drillers term for the Hardinsburg (Hightower shallow) and Bethel (Hightower deep) Sandstones in Indiana.

Hoffner Member

Name applied to clastic rocks with minor limestone of Genevievian age in Union County, Illinois, overlying oolitic limestone of the Fredonia Member of the Ste. Genevieve and underlying sandy *Talarocrinus*-bearing limestone of the Shetlerville Member of the Renault. It comprises the Spar Mountain, Karnak, and Joppa Members of the Ste. Genevieve, the Aux Vases Formation, and the Levias Member of the Renault. The unit is omitted from the present reclassification because the smaller units can be recognized in exceptionally good outcrops or well records, and a unit that includes one formation and parts of two others is hard to classify. However, most outcrops of upper Genevievian rocks in this area are poor, and a unit consisting of all post-Fredonia Genevievian rocks is a practical unit for geologic mapping in the re-

gion. The type section was originally believed younger than the Levias, but comparison with nearby and new complete exposures along interstate Highway 57 has shown the type section to be Joppa, Karnak, and Spar Mountain. Named by J. M. Weller in S. Weller and Krey (1939) for exposures in a creek bed, roadside ditches, and a hill slope north of the creek and west of a secondary road, 0.6 mile north of Chapel church and about half a mile east of the site of Hoffner school, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 8, T. 13 S., R. 1 E., Dongola Quad., Union Co., Ill. (fig. 3, loc. 28).

HOMBERGIAN STAGE

Name, revised and changed to adjectival form in this report, for the middle stage of the Chesterian; overlies the Gasperian Stage and underlies the Elviran Stage. This stage comprises the Fraileys, Haney, Hardinsburg, and Glen Dean Formations and their equivalents. This definition includes all the rocks that normally have been assigned to the Middle Chester Group or the Homberg Group in Indiana and Kentucky, but excludes the Cypress Sandstone and the Beech Creek Limestone, which commonly have been included in the Homberg in Illinois. Named for the Homberg Group (J. M. Weller, 1939), which is in turn named for the town of Homberg, sec. 4, T. 14 S., R. 6 E., Brownfield Quad., Pope Co., Ill. (fig. 3, loc. 34).

Hoover sands

Drillers term for the Hardinsburg (Hoover gas sand) and Big Clifty (Hoover oil sand) Sandstones in Indiana.

Hunt sand

Drillers term for Sample Sandstone in Indiana.

Huron Group

Abandoned preoccupied term used in Indiana as an approximate synonym of Chester, particularly for beds from the base of the Bethel Sandstone upward. Named by Hopkins (1902) for the outcrop about half a mile east of the village of Huron in SW $\frac{1}{4}$ sec. 5, T. 3 N., R. 2 W., Huron Quad., Lawrence Co., Ind. (fig. 3, loc. 74).

Hyneman sand

Drillers term for the Big Clifty Sandstone in Indiana.

Indian Springs Shale

Abandoned or little-used term for the upper shaly part of the Big Clifty Formation of Indiana or for that part of the Fraileys Shale above the Big Clifty Sandstone Member in Illinois. Named by Malott and Thompson (1920) for an outcrop, clearly designated by Malott (1931) a quarter of a mile northwest of the village of Indian Springs, NW $\frac{1}{4}$ sec. 17, T. 4 N., R. 3 W., Indian Springs Quad., Martin Co., Ind. (fig. 3, loc. 78).

Inflatia—see “*Productus*”

Iowa Series

Abandoned time-stratigraphic name applied to all pre-Chesterian Mississippian rocks; equivalent to both the Kinderhookian and Valmeyeran of the present classification. Named by S. Weller (1920a) for the state of Iowa.

Jackson lime

Drillers term used to a limited extent for the Haney Limestone in the Owensboro district of Kentucky.

Jackson sand

Subsurface term used throughout the basin for the Big Clifty Sandstone.

Jett lime

Drillers term for the Vienna Limestone (Jett brown lime or first Jett lime) used throughout Kentucky. The “second Jett lime” is a limestone bed at the top of the Glen Dean Formation in the Owensboro district, Kentucky.

Jett sand

Drillers term used widely, although largely in Kentucky, for the Tar Springs Sandstone. The “second Jett sand” is in the Glen Dean Formation in the Owensboro district, Kentucky.

Jones sand

Drillers term for the Hardinsburg Sandstone in Kentucky.

**JOPPA SANDSTONE MEMBER,
LIMESTONE MEMBER, or
SHALE MEMBER**

Name proposed in this report for shale, sandstone, and limestone of Genevievian age that lie upon relatively pure limestone assigned to the Karnak Member of the Ste. Genevieve Limestone and beneath the more clastic rocks assigned to the Rosiclare Member of the Aux Vases Sandstone. The Joppa is assigned to the Ste. Genevieve Limestone wherever the presence of a prominent limestone bed at its top makes this practical, but to the Aux Vases Sandstone wherever the absence or thinness of the limestone bed makes separation of the Joppa from the Aux Vases impractical. It generally is impractical to distinguish the Joppa from the underlying Karnak in Indiana, Kentucky, and parts of the easternmost Illinois counties. It is impractical or impossible to separate the Joppa from the Aux Vases in most of Illinois west of the third principal meridian and in parts of the counties immediately east of the meridian. In most of southeastern Illinois the Joppa has been called the "Aux Vases lime" and is the unit between the "Indiana Ste. Genevieve top" and the "Illinois Ste. Genevieve top." It is in this region that the Joppa is most useful and is considered a member of the Ste. Genevieve. At its type section (fig. 6) near the southwest corner of the area of usefulness the Joppa is represented by 32 feet of shale, only partially exposed, containing thin, sandy layers near the base and beds of hematitic, oolitic limestone up to a foot or so thick in the upper part. The type section lies upon that of the Karnak Limestone Member and beneath 19 feet of poorly exposed fine sandstone and shale of the Aux Vases (Rosiclare Member), which in turn is overlain by an outcrop of the Levias about 4 feet thick. Named for exposures on a hillside and in the road ditch north of a secondary road leading to Belknap, about 300 feet east of Illinois Highway 37, and half a mile east of the railroad track at Joppa Junction, in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 13 S., R. 2 E., Dongola Quad., Johnson Co., Ill. (fig. 3, loc. 29).

KARNAK LIMESTONE MEMBER

Name proposed in this report for a relatively pure persistent limestone unit in the Ste. Genevieve Limestone of Genevievian age. It generally is 10 to 35 feet thick. It overlies sandstone, siltstone, shale, or impure limestone assigned to the Spar Mountain Member and underlies similar strata assigned to the Aux Vases Sandstone or the Joppa Member. At the type section (fig. 6) the top 16 feet of an estimated 20 to 25 feet of cross-bedded, oolitic limestone is exposed in cuts on Illinois Highway 37. Lower beds are inadequately exposed in the hill slope southeast of the junction of the highway with a gravel road to Belknap. About 300 feet east of the junction, the top of the Karnak lies 51 feet beneath the base of the Levias Limestone Member of the Renault and directly beneath the type section of the Joppa Member. Named for these exposures 4 miles northwest of Karnak, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 13 S., R. 2 E., and NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5, T. 14 S., R. 2 E., Dongola Quad., Johnson Co., Ill. (fig. 3, loc. 29).

Kaskaskia Group

Abandoned, although senior, synonym for Chester (Chesterian); used widely from its naming by Hall (1857) until the 1920's, usually as exact synonym of the Chester of other authors. There were abortive attempts to make each a subordinate division of the other. Named for Kaskaskia, the first capital of the Illinois Territory. The Mississippi River now flows across the site of the old town in sec. 31, T. 6 S., R. 7 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 13).

KASKASKIA "SEQUENCE"

A major regional, unconformity-bounded unit that includes all rocks in the central United States lying between the major intra-Devonian unconformity and the pre-Pennsylvanian unconformity, thus including all Mississippian, Upper Devonian, and all but the earliest Middle Devonian rocks of the region. Although Chesterian rocks were first excluded from this unit and placed in the overlying Absaroka "Se-

quence," they later were included in the Kaskaskia (Sloss, 1959; Swann and Willman, 1961). Named by Sloss, Krumbein, and Dapples (1949) for many thoroughly logged and sampled wells penetrating a typical development of the sequence within the drainage basin of the Kaskaskia River in south-central Illinois.

Kentucky Shale

Abandoned, little-used name applied in eastern Kentucky to the section above the Glen Dean Limestone and beneath the Lee (Pennsylvanian), and thus corresponding essentially to the Pennington Formation or to the Elviran Stage. Named by Shaler (1877), presumably for the headwaters of the Kentucky River.

KINKAID LIMESTONE or FORMATION

Limestone and shale of Elviran age restricted in this report by removal of the Grove Church Formation at the top; lies upon clastic rocks assigned to the Degonia Formation and beneath shales (with only minor limestones) assigned to the Grove Church Formation. It comprises three members, of which the upper and lower are massive limestone units 18 to 40 feet thick and the middle is a shale and limestone sequence 60 to 100 feet thick. Named by S. Weller (1920a) for exposures along Kinkaid Creek, the most prominent of which are in the SE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 6, T. 8 S., R. 4 W., Campbell Hill Quad., Jackson Co., Ill. (fig. 3, loc. 19).

Kirkwood sand or sands

Drillers term applied in southeastern Illinois primarily to the Cypress Sandstone, although lower units were sometimes included as the "third" and "fourth" Kirkwood.

Klein sand

Drillers term reportedly used in Marion County, Illinois, but not identifiable. May be error for Stein.

Leitchfield flagstone

Commercial term for Hardinsburg Sand-

stone quarried near Leitchfield, Grayson County, Kentucky.

Leitchfield Shale

Name used since its reintroduction and redefinition by J. M. Weller (1927) for all Elviran rocks present near the southeast corner of the basin in Kentucky where these rocks are largely shale. Although shown on charts as extending from the Tar Springs through the Kinkaid, the name is used largely in areas where no Chesterian formations younger than the Menard exist, and it actually has been applied primarily to shales equivalent to Tar Springs and Waltersburg. In its original usage the name also was applied to shales equivalent to the Hardinsburg Sandstone. Named by Norwood (1876) for outcrops near Leitchfield, perhaps those in the immediate vicinity of the town in 8-L-39, Leitchfield Quad., but probably those about a mile west of the station at Grayson Springs (now Clarkson) in 5-L-40, Clarkson Quad., Grayson Co., Ky. (fig. 3, loc. 54).

LEVIAS LIMESTONE MEMBER

Relatively pure limestone of latest Genevievean age, in this report considered the lower of two members of the Renault Formation, although originally assigned to the Ste. Genevieve. It overlies the Aux Vases Sandstone and underlies the Shetlerville Member of the Renault. The Shetlerville is also characterized by limestone, but its basal few inches or few feet generally are more clastic than the Levias. The Levias is distinguished from the Shetlerville paleontologically by bearing *Platycrinites penicillus* and lacking *Talarocrinus*. Lithologic distinctions are minor. The Levias generally is lighter in color than the Shetlerville but contains some dark lithographic limestone. It is less silty, less sandy, with larger, more spherical oolites that tend to be white or pink in color and to lack dark centers. The top of the Levias is brecciated in many localities to form the Bryantsville Breccia Bed. Named by Sutton and J. M. Weller (1932) for outcrops on the hillside east of the town of Levias, 10-J-16, Salem Quad., Crittenden Co., Ky. (fig. 3, loc. 43).

Lindley sands

Drillers term for the Cypress (upper Lindley) and the Yankeetown (lower Lindley) Sandstones in Bond County, Illinois.

Lithodrumus—see "*Campophyllum*"

"*Lithostrotion canadensis*"—see *Lithostrotionella castelnaui*

***Lithostrotion harmodites* Zone**

Zone in Kentucky and Indiana characterized by an abundance of a small-tubed colonial coral, and generally employed as a peak zone. It has not yet been found in Illinois but is approximately equivalent to the Joppa Member of the Ste. Genevieve. At a few localities, this coral appears to have been found in beds equivalent to the underlying Karnak Member and in beds that may be equivalent to the overlying Aux Vases or to the Levias Member.

***Lithostrotionella castelnaui*=="*Lithostrotion canadensis*" Assemblage Zone**

Zone characterized by this conspicuous, large-celled, massive, compound coral and the digitate *Lithostrotion proliferum*; generally equivalent to the St. Louis Limestone. The disappearance of these corals from the Mississippi Valley region marked the beginning of Genevievian time.

Little lime

Drillers term sometimes applied to the Glen Dean Limestone or more particularly to the lower massive member of the Glen Dean in Kentucky.

Lockhart Formation

Abandoned name, defined only as overlying the Birdsville Formation; probably used for the Kinkaid, Degonia, Clore, and, possibly, the Palestine Formations in western Kentucky. Named by Fohs (1907), apparently for Lockhart Bluff, east edge of 23-J-15, Lola Quad., Livingston Co., Ky. (fig. 3, loc. 44).

LOST RIVER CHERT BED

Fossiliferous, rough-weathering chert or cherty limestone, 1 to 6 feet thick, occurring 10 to 35 feet above the base of the Fredonia Member of the Ste. Genevieve Limestone in

Indiana and Kentucky. The Ste. Genevieve-St. Louis boundary in the past has been placed both above and beneath this bed but has been maintained consistently several feet beneath it since 1943. Named by Elrod (1899) for occurrences along Lost River, south of Orangeville, in and near sec. 7, T. 2 N., R. 1 W., French Lick and Georgia Quads., Orange Co., Ind. (fig. 3, loc. 73).

Loveless sand

Drillers term for the Tar Springs Sandstone in Indiana.

Lusk Limestone

Name used only once on a chart as a synonym of the Golconda Group. The same geographic term is now applied to a member at the base of the Pennsylvanian. Named by Keyes (1923), presumably for Lusk Creek which enters the Ohio River at Golconda in sec. 19, T. 13 S., R. 7 E., Golconda Quad., Pope Co., Ill. (fig. 3, loc. 35).

McClosky lime or sand

Drillers term widely applied to zones of coarse oolitic limestone at several levels in the Fredonia Member of the Ste. Genevieve Limestone. Occasionally spelled McCloskey or McCrosky.

**MAMMOTH CAVE LIMESTONE
MEGAGROUP**

The main body of carbonate rocks of Mississippian age in the Midwest. It overlies the Knobs Megagroup which is an eastward-thickening sequence of clastic rocks of Devonian-Mississippian age, and underlies the Pope Megagroup whose base is marked by the lowest locally prominent sandstone of late Valmeyeran or Chesterian age. Its top is within the St. Louis equivalent in Iowa. However, its top is at the top of the St. Louis in central Illinois, the Fredonia in southwestern Illinois, the Karnak in south-central Illinois, the Joppa in most of southeastern Illinois, the Downeys Bluff in the fluorspar district and lower Wabash Valley, the Beaver Bend and Reelsville in small areas in Indiana and Kentucky, the Beech

Creek in west-central Kentucky, the Haney in east-central and northeastern Kentucky, and the Glen Dean (or possibly Vienna) in southeastern Kentucky. The name was extended by Swann and Willman (1961) from the Mammoth Cave Group of Miller (1917). Named for Mammoth Cave in the southeast part of I-41, Mammoth Cave Quad., Edmonson Co., Ky. (fig. 3, loc. 53).

Marigold Oolite Member

Little-used name for a series of light colored oolitic beds in the Haney Limestone. Named by Sutton (1934a) for several exposures in the vicinity of Marigold, SE $\frac{1}{4}$ sec. 20, T. 5 S., R. 8 W., Renault Quad., Randolph Co., Ill. (fig. 3, loc. 9).

Martinia contracta fauna

The brachiopod fauna of the Beech Creek Limestone or of the upper part of the Beech Creek. The fauna is dominated by *Martinia contracta* and *Inflatia inflata*.

MENARD LIMESTONE or FORMATION

Limestone and associated shale of Elviran age lying upon clastic rocks of the Waltersburg Formation and underlying the Palestine Sandstone. The Menard includes three named limestone members separated by unnamed shales. The lower, or "little Menard," is named the Walche Limestone Member. The middle, or "massive Menard," is named the Scottsburg Limestone Member. The upper limestone is named the Allard Limestone Member. Where the Walche Member is absent in the northern part of the basin, the base of the formation is placed at the base of the Scottsburg Member. The original usage included the Waltersburg, which is a shale about 35 feet thick in the Menard type area. Named by S. Weller (1913) for exposures in quarry faces in the Illinois State Penitentiary at Menard, NE $\frac{1}{4}$ sec. 23, T. 7 S., R. 7 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 15).

Meramecan (Meramecian) Series

A major time-stratigraphic division of the Mississippian overlying the Osagian

and underlying the Chesterian. It is considered by many American stratigraphers the next to the youngest of four series in the Mississippian. It is currently considered the upper of two units of indeterminate rank in the Valmeyeran Series by the Illinois Geological Survey and the lower of two provincial series in the Upper Mississippian Series by the United States Geological Survey. The lower boundary in commonest use corresponds to the base of the Warsaw, but the Warsaw is excluded by the Illinois Survey, and the Salem also has been excluded by some. Before 1920 the top generally was placed at the top of the St. Louis. Since 1937, the Meramecan has consistently included the Ste. Genevieve, and in a few reports has included beds as young as the Haney or even Glen Dean. Although called the Meramec Group in much of the literature, it has been employed from its inception as a time-oriented rather than a rock-oriented unit and should have an adjectival ending. The spelling Meramecan makes pronunciation easier than the form Meramecian. Named by Ulrich in Buckley and Buehler (1904) for the Meramec Highlands in the western part of St. Louis County, Missouri.

Millerella Assemblage (?) Zone

A fusulinid zone characterized by the presence of this primitive short-axised form and by the absence of *Profusulinella* and other more advanced fusulinids. It includes late Elviran as well as early Pennsylvanian strata.

Mississippi lime

Informal term essentially equivalent to the Mammoth Cave Limestone Megagroup.

Mitchell Limestone or Group

Name, now little used, applied in Indiana most consistently to the section from the base of the St. Louis through the Paoli Limestone, but at times contracted to include only the St. Louis of current usage and at other times expanded to include units as high as the Beech Creek. Named by Siebenthal and Hopkins (1897) for the town of Mitchell, sec. 36, T. 4 N., R. 1 W.,

Mitchell Quad., Lawrence Co., Ind. (fig. 3, loc. 76).

Monroe City sand

Drillers term for a sandstone, probably the Popcorn Sandstone Bed, in the Paoli Limestone in Indiana.

Monte Sano (also Monte Sana, Montesano) Group

Abandoned name used in Kentucky and Illinois largely for rocks of Genevievian and Gasperian age, particularly where they are limestone. It probably included younger rocks elsewhere. Used by Ulrich in 1911 in a table only, it was first clearly defined by him in 1917 for exposures at Monte Sano, Huntsville Quad., Madison Co., Ala.

Mooretown Sandstone, Shale, or Formation

Synonym of Bethel Sandstone now abandoned in Indiana but still used in parts of Kentucky where the name Bethel was applied to the Sample Sandstone until very recently. Named by Cumings (1922) for cuts along the Baltimore and Ohio Railroad, along Indiana Highway 60 1.8 miles east of its junction with U. S. 50, and near the abandoned village of Mooretown (Moorestown), S $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 3, T. 3 N., R. 2 W., Georgia Quad., Lawrence Co., Ind. (fig. 3, loc. 75).

Mountain limestone

Name carried over from southwestern England and applied in many early reports to the main body of limestone of Mississippian age, essentially the Mammoth Cave Limestone Megagroup.

Mt. Olympus sand

Drillers term used in Indiana for either the Big Clifty or the Cypress Sandstone.

Mt. Pleasant Sandstone, Shale, or Formation

Abandoned synonym for Degonia Sandstone. First used by Logan (1924) but formally named by Malott (1925) for exposures in the heads of several ravines near the town of Mt. Pleasant, which is situated on a structural plane underlain by this

sandstone in the SE $\frac{1}{4}$ sec. 33, T. 4 S., R. 1 W., Derby Quad., Perry Co., Ind. (fig. 3, loc. 65).

NEGLI CREEK LIMESTONE MEMBER

This name had been abandoned as a synonym of the Kinkaid Limestone but is revived in this report for the lowest member of the Kinkaid. A massive limestone unit of Elviran age 15 to 40 feet thick overlying the Degonia Sandstone and underlying several feet of shale at the bottom of the Cave Hill Member of the Kinkaid. Name first used by Logan (1924) but formally defined by Malott (1925) for a single massive ledge of limestone 12 feet thick on the west bank of Negli (also spelled Neglie) Creek, NW $\frac{1}{4}$ sec. 36, T. 6 S., R. 3 W., Cannelton Quad., Perry Co., Ind. (fig. 3, loc. 64).

New Design Group

A group formally abandoned in this report, which had strong time-stratigraphic connotations, essentially equivalent to the Gasperian Stage. It was interpreted in Indiana and Kentucky as the exact equivalent of Gasperian. In Illinois it included the Aux Vases Sandstone, herein considered Genevievian, and excluded the Cypress and Beech Creek Formations, which in this report are placed in the Gasperian. Named by J. M. Weller (1939) for New Design Township, which includes most of T. 3 S., R. 9 W., Renault and Waterloo Quads., Monroe Co., Ill. (fig. 3, loc. 2).

Nixon sand

Drillers term for Sample Sandstone in Indiana. Also appears as Nixom, probably in error.

Oakland City sand

Drillers term for Bethel Sandstone in Indiana.

Oblong lime or sand

Drillers term for porous oolitic zones in the Ste. Genevieve Limestone in Crawford County, Illinois.

Ohara (lower Ohara) lime

Subsurface term widely and consistently applied to the Karnak Limestone Member of the Ste. Genevieve, or to an oolitic pay zone within it. This is beneath the Aux Vases Sandstone, whereas the abandoned Ohara Limestone (renamed the Cedar Bluff Group) was above it.

Ohara Limestone

Abandoned name formerly applied to the Cedar Bluff Group. Reinstatement of Ohara in its original meaning would cause confusion because of its current widespread and consistent use in the subsurface of the deeper part of the basin for an older unit. Named by Ulrich (1905) for the former Ohara quarry at Cedar Bluff about 3 miles east of Princeton, S $\frac{1}{2}$ 21-H-20, Princeton East Quad., Caldwell Co., Ky. (fig. 3, loc. 48).

Ohio River Formation

Largely unconsolidated sand, with minor amounts of clay of doubtful age, lying in channels cut in various Valmeyeran formations east of the Chesterian outcrop belt in Indiana and west-central Kentucky. Although it is now considered Tertiary by some (Pinsak, 1956; Wayne, 1960), I agree with Ray et al. (1947) who correlated it with the Bethel Sandstone. The formation was deposited as a channel fill that can be traced from Indiana through scattered outcrops (Tip Top Sand) in the Fort Knox and Rock Haven Quadrangles, Kentucky, into a Paleozoic sandstone that is overlain by Pennsylvanian at Snow Mountain, Rock Haven Quadrangle. It extends southwestward as Sand Ridge, Flaherty Quadrangle, into the channel deposit of Bethel (Mooretown) Sandstone noted by Stouder (1938, 1941) in the Constantine and Howe Valley Quadrangles, Kentucky. Named by Ashley (1903) for exposures at the crest of the Knobstone Escarpment west of the Ohio River, particularly in Ts. 4 and 5 S., R. 5 E., Lanesville and Kosmosdale Quads., Harrison Co., Ind.

OKAW LIMESTONE GROUP

Name used only in western Illinois for

formations from the Beech Creek through the Glen Dean where the clastic units are poorly developed and it is difficult to assign many small limestone outcrops to the proper formation. At first the Tar Springs and Vienna Formations were included in the unit. Sutton (1934a) added the Waltersburg Formation, and Weller and Weller (1939) removed the Tar Springs, Vienna, and Waltersburg Formations. S. Weller (1920a) used the term in two senses—1) Okaw Limestone as in his other papers and 2) Okaw Group, which included the Cypress Sandstone in addition to his Okaw Limestone. Named as a formation by S. Weller (1913) for the Okaw or Kaskaskia River, whose valley is incised in it through Ts. 4, 5, and 6 S., Rs. 7 and 8 W., Baldwin Quad., Randolph Co., Ill.

Orange-Martin Limestone

Abandoned term for several Chesterian formations in Indiana not specifically identified but probably including the Beech Creek and Haney. Named by Owen and Owen (1862) for Orange and Martin Counties, Indiana.

PAINT CREEK GROUP

Name hopefully restricted in this report to its original use in western Illinois for the units of Gasperian age now placed in the Ridenhower, Bethel, and Downey Bluff Formations. It is proposed that the use of the term be abandoned for the Ridenhower in the fluorspar district and the deep basin area; for the Beech Creek, Cypress (Elwren), and Ridenhower, or for the Beech Creek, Cypress, and Reelsville in the rest of Indiana and most of the rest of Kentucky; for the Reelsville alone in the shallow subsurface area at the eastern edge of the basin in Kentucky. Named as a formation by S. Weller (1913) for outcrops in the valley of Paint Creek and its tributaries, typical of which are those in the north-flowing tributary west of McCuen school, E $\frac{1}{2}$ sec. 2, T. 5 S., R. 9 W., Renault Quad., Randolph Co., Ill. (fig. 3, loc. 5).

Paint Creek lime

Term used as an informal subsurface

name for the following: in western Illinois for the Ridenhower (upper Paint Creek) and Downeys Bluff (lower Paint Creek); in the subsurface of eastern Illinois and westernmost Indiana north of Gibson County, for the Ridenhower; in the subsurface of the more eastern Indiana counties for the Reelsville (upper Paint Creek) and the Beaver Bend (lower Paint Creek); in the shallow subsurface at the eastern edge of the basin in Kentucky for the Reelsville.

Paint Creek sand

Subsurface term for the Bethel Sandstone in western Illinois and the Sample Sandstone in Indiana and parts of western Kentucky and eastern Illinois.

PALESTINE SANDSTONE or SHALE

Sandstone with associated shale and thin coal of Elviran age overlying limestone and calcareous shale of the Menard Formation and underlying limestone or relatively finer grained or calcareous shale of the Clore Formation. Named by S. Weller (1920a) for Palestine Township, where the formation is well exposed in tributaries to Tyndall Creek in secs. 29 and 30, T. 6 S., R. 6 W., Chester Quad., Randolph Co., Ill. (fig. 3, loc. 14).

Paoli Limestone

Formation recognized in outcrops in Kentucky and Indiana (Cumings, 1922) for the equivalents of the Shetlerville Member (lower Paoli), the Yankeetown Formation (middle Paoli), and the Downeys Bluff Limestone (upper Paoli). In the subsurface of these states the term has been extended downward to the top of the Aux Vases Sandstone (Pinsak, 1957) and thus includes the Levias Limestone Member and is the exact equivalent of the Cedar Bluff Group. The Paoli originally included most of the Ste. Genevieve Limestone down to the top of the Lost River Chert Bed. Named by Elrod (1899) for outcrops in and near the town of Paoli, sec. 36, T. 2 N., R. 1 W., and sec. 1, T. 1 N., R. 1 W., Paoli Quad., Orange Co., Ind. (fig. 3, loc. 71).

Pella Shale

Fossiliferous shale with interbedded limestone lenses of Genevievean and Gasperian age in central Iowa, equivalent to the Ste. Genevieve, Aux Vases, Renault, and probably the Yankeetown and Downeys Bluff Formations, commonly called the Pella Beds. Named by Bain (1895) for outcrops near Pella, Marion County, Iowa.

Pellville sand

Drillers term reportedly used in the shallow oil fields of northern west-central Kentucky, but not identifiable.

Pencil cave

Descriptive drillers term applied to, among many other units, the Hardinsburg Shale in eastern Kentucky and easternmost western Kentucky.

Pennington Shale

Name used in eastern Kentucky, Virginia, and Tennessee for the Elviran rocks from the top of the Glen Dean Limestone to the base of the lowest prominent conglomerate of Elviran or Pennsylvanian age, and occasionally used with the same meaning in western Kentucky. Named by Campbell (1893) for section at Pennington Gap, Lee County, Virginia.

Penrod sand

Drillers term for Hardinsburg or possibly Big Clifty Sandstone in Muhlenburg County, Kentucky.

***Pentremites* or pentremital limestone**

Term used in some early reports for any or all of the limestones of Genevievean and Chesterian age. Several short-ranged species of *Pentremites* are particularly useful in stratigraphic work (Galloway and Kaska, 1957). Early collections had little stratigraphic control, but modern placement of the localities available to early collectors shows that many ranges are much shorter than the compilation suggests.

***Pentremites fohsi* Range Zone**

Range zone formalized by S. Weller (1926) in the lower part of the Menard Formation, probably corresponding to the

unnamed shale member between the Walche and Scottsburg Limestone Members, plus the lower part of the Scottsburg.

Petersburg sand

Drillers term for Bethel Sandstone in Indiana.

Pink crinoidal lime

Descriptive term for the Downeys Bluff Limestone, particularly in western Illinois.

***Platycrinites* "*Platycrinus*" *penicillus* "*huntsvilleae*" Zone**

A zone marked by the distinctive spiny elliptical stem segments or the flattened pentagonal basal cup of this crinoid (and perhaps by the absence of the coral *Lithostrotionella castelnaui*); equivalent to the Genevievian. The crinoid occurs rarely in the underlying St. Louis Limestone. The Genevievian-Chesterian boundary is placed above the highest occurrence of this fossil and beneath the lowest occurrence of *Talarocrinus* (other than *T. simplex*).

Plum Creek Beds

Abandoned, preoccupied name applied to the upper part of the Glen Dean and possibly to all or parts of the Tar Springs and Vienna Formations in southwestern Illinois. Named rather informally by Ulrich (1917), obviously, though not explicitly, for exposures along Plum Creek and its tributaries in and near sec. 9, T. 5 S., R. 7 W., Baldwin Quad., Randolph Co., Ill. (fig. 3, loc. 8).

POPCORN SANDSTONE BED

Name proposed in this report for a bed of sandstone, shale, or impure limestone of earliest Gasperian age that forms the basal few inches or few feet of the Shetlerville Member of the Renault Formation in Illinois or of the Paoli Formation in Indiana and Kentucky. It underlies purer limestone beds forming the rest of these units and overlies the Levias Limestone Member of the Renault Formation or beds assigned to the Ste. Genevieve that are equivalent to the Levias. Named here for an exposure (fig. 7) suggested by H. H. Gray about 50

feet above Popcorn Spring, which is 3½ miles northwest of Springville, 700 feet west of Popcorn church and 200 feet north of the section line, SE¼ SE¼ SW¼ sec. 5, T. 6 N., R. 2 W., Owensburg Quad., Lawrence Co., Ind. (fig. 3, loc. 79).

POPE MEGAGROUP

The sequence of alternating clastic and limestone units of late Valmeyeran and Chesterian age overlying the Mammoth Cave Limestone Megagroup and underlying the Pennsylvanian in the central United States. The base of the megagroup is placed at the base of the lowest well developed clastic unit in any area. It is at the base of the Fredonia, Spar Mountain, Aux Vases, possibly Yankeetown, Bethel, possibly Sample or Cypress, and Big Clifty in different parts of the Illinois Basin, and at older or younger horizons elsewhere. The megagroup is the rock-stratigraphic, as opposed to the time-stratigraphic, component of the early concept of the Chester Group. Named by Swann and Willman (1961) for Pope County, Illinois.

Princeton Limestone

Abandoned, preoccupied name for the Ste. Genevieve, Aux Vases, Renault, Yankeetown, and Downeys Bluff Formations or their equivalents in western Kentucky. Named by Ulrich (1903) for the town of Princeton, 17 and 18-H-20, Princeton East and Princeton West Quads., Caldwell Co., Ky. (fig. 3, loc. 47).

***Prismopora serrulata* Zone**

A term applied at different times to the Glen Dean Limestone, the Glen Dean and Golconda, the Vienna, and the interval from Vienna through Golconda (Haney?). This distinctive bryozoan, which has a triangular cross-section and serrate edges, is common in the Glen Dean and once was believed confined to that formation. It later was found to be common in some outcrops of the Haney and more recently in the lower part of the Cave Hill Member of the Kinkaid. It also occurs in the Fraileys, Vienna, and Clore.

***“Productus” inflatus=Inflatia inflata=*
“Dictyoclostus” inflatus Assemblage
 Zone**

An assemblage zone used in Kentucky as equivalent to the Beech Creek Limestone. This and several associated brachiopods have much longer ranges but are particularly abundant in the Beech Creek.

Pterotocrinus

This camerate crinoid genus lived throughout the Chesterian, and its species provide excellent zonation of the series. Complete calices are very rare, but there were five large distinctive wing plates between the arms, and the species can be identified by isolated wing plates. The treatment of the genus by Sutton (1934b) outlines the evolution of the genus and is a very useful reference for stratigraphic paleontology of the Chesterian. Revision of the Elviran forms, particularly those of the Kinkaid which were rather sparsely represented in Sutton's material, would further increase the usefulness of the genus. In general, small blade-shaped plates occur in the Gasperian, simple at first but developing into broadened spade-shaped and digitate forms in the late Gasperian. Large, simple, and forked blades as well as heavy massive plates characterize the Hombergian. The Elviran is dominated by pointed and triangular shapes, although other forms also occur.

***Pterotocrinus acutus* and *Pterotocrinus bifurcatus* Assemblage Zone**

An assemblage zone equivalent to the Glen Dean Limestone. The two named species are confined to the Glen Dean. The other elements in the assemblage noted by S. Weller (1926) are *Pentremites brevis* and *Pentremites spiculatus*, both confined to the Glen Dean, and the bryozoans *Archimedes laxa* and *Prismopora serrulata*, which are abundant but not confined to the Glen Dean.

***Pterotocrinus capitalis* Range Zone**

A range zone formalized by S. Weller (1926), equivalent to approximately the lower half of the Fraileys Shale.

Pugnoides ottumwa

This small plicate brachiopod was once believed confined to the Pella and the Ste. Genevieve, where it is very abundant in certain beds, but it has been found in the St. Louis, Shetlerville, and Beech Creek.

**REELSVILLE LIMESTONE MEMBER
 or SHALE MEMBER**

Limestone and shale of Gasperian age forming the upper member of the Ridenhower Formation in Illinois, but given formational rank in Indiana and Kentucky. It overlies clastic rocks assigned to the Sample and underlies those assigned or equivalent to the Cypress. Named by Mallott (1919) for a limestone and shale unit 21½ feet thick, the highest of three limestone units in a roadcut on the south bank of Eel River, also called Walnut Creek, just south of Reelsville, SE¼ SW¼ NE¼ sec. 21, T. 13 N., R. 5 W., Reelsville Quad., Putnam Co., Ind. (fig. 3, loc. 84).

**RENAULT LIMESTONE,
 FORMATION, or SHALE**

Limestone, shale, and associated sandstone of latest Genevievean and earliest Gasperian age, that overlie dominantly clastic rocks assigned to the Aux Vases Sandstone and underlie those assigned to the Yankeetown Formation. Because the Levias Limestone Member in the fluorspar district overlies the Aux Vases Sandstone, in this report it is transferred from the Ste. Genevieve to the Renault. Shale beds that have been considered middle Renault in eastern Illinois and nearby Indiana and Kentucky are assigned to the Yankeetown and the beds that have been called upper Renault in this area are assigned to the Downeys Bluff. Named by S. Weller (1913) for Renault Township, where no specific type section was indicated but where the formation is well exposed in the valley of Horse Creek and its tributaries; a typical outcrop is in the lowest gully on the south side of Dry Fork in the SE¼ SW¼ sec. 23, T. 4 S., R. 9 W., Renault Quad., Monroe Co., Ill. (fig. 3, loc. 3).

RIDENHOWER FORMATION, SHALE, LIMESTONE, or SANDSTONE

Variable formation of Gasperian age, with higher carbonate and finer clastic content than the underlying Bethel and overlying Cypress Sandstones. In a belt 20 or 30 miles wide along the Wabash River, the Ridenhower is composed of clastics very similar to those of the Bethel and Cypress. East of this clastic belt in Indiana and Kentucky, the beds equivalent to the Ridenhower generally are placed in three well marked formations, the Reelsville Limestone, Sample Sandstone, and Beaver Bend Limestone, in descending order. In Illinois west of the clastic belt, the separation of these units is much more difficult and they are considered members of the Ridenhower. Named by Butts (1917) for fossiliferous shale about 40 feet thick poorly exposed between the Bethel and Cypress in the bluff above the railroad cut and road at Indian Point, $\frac{3}{4}$ of a mile southeast of Forman, nearly 5 miles south of Ridenhower school, SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 32, T. 13 S., R. 3 E., Vienna Quad., Johnson Co., Ill. (fig. 3, loc. 30).

Rock House Sandstone

Name used incidentally by Owen (1857) as a synonym for Tar Springs Sandstone in his original description of that unit, although the sandstones exposed at Rock House are the Sample, Cypress, and perhaps the lower part of the Big Clifty. Named for "the Rock House" on Shot Pouch Creek, probably a natural feature in the cliff-walled canyon in 6, 15, or 16-Q-37 Lodiburg and Hardinsburg Quads., Breckinridge Co., Ky. (fig. 3, loc. 61).

Rockwood Sandstone

Abandoned, preoccupied term for Palestine Sandstone. Name used only in table by S. Weller in Blatchley (1913), obviously though not explicitly derived from the town of Rockwood in secs. 7 and 18, T. 8 S., R. 5 W., Campbell Hill Quad., Randolph Co., Ill. (fig. 3, loc. 18).

Rosiclare sand

Subsurface term, used widely for a pay zone in sandstone or limestone at the level of the Spar Mountain Sandstone Member, which is typically 30 to 70 feet beneath the position of the type Rosiclare (Aux Vases).

ROSICLARE SANDSTONE MEMBER or SILTSTONE MEMBER

Fine-grained sandstone, siltstone, and associated shale of Genevievian age overlying limestone, shale, or relatively coarser sandstone of the Joppa Member, and underlying limestone and associated shale of the Renault Formation. Rosiclare is nearly synonymous with Aux Vases and is recognized here as a member of that formation. It is co-extensive with the formation (and therefore of limited usefulness) in eastern Illinois, Kentucky, and Indiana. However, in western Illinois, the underlying Joppa is so sandy that it is included in the Aux Vases, and the term Rosiclare is retained for the main, upper, relatively fine-grained part of the Aux Vases. Except in its type area, the fluorspar district, the name Rosiclare commonly has been misapplied to the Spar Mountain Sandstone Member, which is 30 to 70 feet lower. Named by Ulrich (1905) for outcrops in Downeys and Fairview Bluffs on the Ohio River just below Rosiclare in the NW $\frac{1}{4}$ SE $\frac{1}{4}$ and the SW $\frac{1}{4}$ SE $\frac{1}{4}$, respectively, sec. 5, T. 13 S., R. 8 E., Rosiclare Quad., Hardin Co., Ill. (fig. 3, loc. 38).

Ruma Formation

Abandoned synonym for the Cypress Formation in southwestern Illinois. Named by S. Weller (1913) for exposures in tributaries to Horse Creek west and northwest of the town of Ruma, typical of which are exposures in the east fork of a tributary flowing through the center of NE $\frac{1}{4}$ sec. 31, T. 4 S., R. 8 W., Renault Quad., Randolph Co., Ill. (fig. 3, loc. 6).

St. Francisville sand

Drillers term for the Bethel Sandstone in Lawrence County, Illinois, and Knox County, Indiana.

Ste. Genevieve Group

Abandoned name used only once for the Warsaw and all younger Mississippian formations. Named by Williams (1922), in a publication issued posthumously more than 30 years after its preparation, for either the town or county of Ste. Genevieve, Missouri.

**STE. GENEVIEVE LIMESTONE
or FORMATION**

Dominantly oolitic or fossil-fragment limestone associated with other limestones, shales, and sandstones of Genevievian age, overlying finer grained, chertier, darker limestones of the St. Louis, and underlying the Aux Vases Sandstone. Where the Aux Vases cannot be recognized in the eastern part of the Illinois Basin and eastward, the Ste. Genevieve extends upward to the base of *Talarocrinus*-bearing beds assigned to the Shetlerville, Paoli, or Gasper. There are two significant steps down to the west in the upper surface of the Ste. Genevieve Formation. One is the thickness of the Levias Member, 5 to 30 feet, at the eastern edge of recognition of the Aux Vases near the eastern margin of the basin. The second is the thickness of the Joppa Member ("Aux Vases lime"), 20 to 40 feet, in south-central Illinois where the Joppa changes westward from dominantly limestone to dominantly sandstone. Named by Shumard (1860) for outcrops in the Mississippi River bluffs 1 to 4 miles southeast of Ste. Genevieve in the northern part of T. 37 N. and southern part of T. 38 N., R. 9 E., extended, Weingarten Quad., Ste. Genevieve Co., Mo. (fig. 3, loc. 11).

Ste. Genevieve Sandstone

Abandoned synonym for Aux Vases Sandstone. Named by Gallaher (1898) for quarries near the top of the Mississippi River bluffs about 4 miles southeast of Ste. Genevieve and three-fourths of a mile north of the Aux Vases River, NE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 11, T. 37 N., R. 9 E., extended, Weingarten Quad., Ste. Genevieve Co., Mo. (fig. 3, loc. 11 or 12).

ST. LOUIS LIMESTONE

Limestone, generally fine grained, dark

colored, compact, cherty, commonly brecciated, with associated evaporite and fine-grained dolomite, of pre-Genevievian Valmeyeran age; overlies lighter oolitic and fossil fragmental limestones assigned to the Salem and underlies similar beds assigned to the Ste. Genevieve. Both the Salem and Ste. Genevieve originally were part of the St. Louis, and various authors have at times included in the St. Louis many units now considered Chesterian or Genevievian. Named by Engelmann (1847) for exposures in St. Louis, Missouri.

**SAMPLE SANDSTONE MEMBER
or SHALE MEMBER**

Variable unit dominated by shale or sandstone of Gasperian age, overlying limestones or fine clastics placed in the Beaver Bend and underlying those placed in the Reelsville. All three units are considered members of the Ridenhower Formation in Illinois but separate formations in Indiana and Kentucky. Named by Butts (1917) for exposures in cuts on the Louisville and Nashville Railroad on the north bank of Sinking Creek about 1 mile east of the town of Sample, near the northeast corner of 7-Q-37, Lodiburg Quad., Breckinridge Co., Ky. (fig. 3, loc. 62).

SCOTTSBURG LIMESTONE MEMBER

Name proposed in this report for the middle "massive Menard" of the three major limestone members of the Menard Formation of Elviran age. It is separated from the upper or Allard Limestone Member by 15 to 30 feet of shale with some limestone beds, and from the lower or Walche Limestone Member by 3 to 30 feet of shale. North of the limits of the Walche Member this shale is included in the Waltersburg Formation, and the Scottsburg becomes the lowest unit in the Menard. The member is about 32 feet thick at its type section (fig. 8), but the upper part of the unit is obscured by both slumping and faulting and only the lower 16 feet is well exposed overlying 14 feet of shale, which in turn overlies the type section of the Walche Member. Named for the exposure in Walche's cut

on the Illinois Central Railroad about 3 miles northeast of Scottsburg in the southwest corner of 19-H-21, 6400 feet from the south line and 8600 feet from the east line of H-21, Princeton East Quad., Caldwell Co., Ky. (fig. 3, loc. 49).

SHETLERVILLE MEMBER or LIMESTONE MEMBER

Limestone and associated shale and sandstone of earliest Gasperian age, forming the upper and more extensive of two members of the Renault Formation. It overlies relatively pure limestone of the Levias Member in most of the basin, but extends beyond it to overlie the Aux Vases Sandstone at the western and northern edges. It underlies clastic rocks of the Yankeetown Formation and in this report is restricted to the lower part of the unit as originally described by placing the upper shaly part in the Yankeetown. It is equivalent to the lower nonshaly part of the Paoli Limestone in Indiana. A basal sandy or silty zone is differentiated in some places as the Popcorn Sandstone Bed. The Shetlerville is distinguished paleontologically from the underlying Levias Member of Genevievean age by the presence of *Talarocrinus* and the absence of *Platycrinites penicillus*. It tends to be darker, siltier, sandier, and less brecciated than the Levias. Named by S. Weller (1920b) but here restricted to the limestone forming the bottom 13 to 15 feet of the type section in an abandoned quarry along the Illinois Central Railroad tracks about a quarter of a mile south of Shetlerville, SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 35, T. 12 S., R. 7 E., Shetlerville Quad., Hardin Co., Ill. (fig. 3, loc. 37).

Shot Pouch Coal Bed

Valid name, not used since its introduction, for a bed of coal or coaly shale in the upper part of the Bethel Formation, extending over a large area in Indiana and in west-central Kentucky. It was applied in a stratigraphic column in which it lies a few feet beneath the Shot Pouch (Sample) Sandstone, from which it is separated by a

fossiliferous limestone (Beaver Bend). Named by Owen (1856) for Shot Pouch Creek, where the coal should crop out near the creek mouth in 6-Q-37, Lodiburg Quad., Breckinridge Co., Ky. (fig. 3, loc. 61).

Shot Pouch Sandstone

Abandoned name, listed as a synonym of Tar Springs in the introduction of the latter although the sandstones that outcrop on Shot Pouch Creek are the Sample, the Big Clifty, and perhaps the Cypress, rather than the Tar Springs. Named by Owen (1856, 1857) for Shot Pouch Creek, whose rock-walled valley lies in the eastern part of 6, 15, and 16-Q-37, Lodiburg and Hardinsburg Quads., Breckinridge Co., Ky. (fig. 3, loc. 61).

Siberia Limestone

Abandoned synonym for the Menard Limestone in southern Indiana. Name first used by Malott and Thompson (1920) but properly introduced by Malott (1925) for a section in the J. Schilling quarry 2 $\frac{1}{2}$ miles southeast of the village of Siberia, in sec. 36, T. 3 S., R. 3 W., Bristow Quad., Perry Co., Ind. (fig. 3, loc. 67).

Sloans Valley Limestone

Abandoned, although senior, synonym of Glen Dean Limestone. It was used only in Illinois by several authors in the volume in which it was introduced, anticipating Butts (1917), who, however, substituted the name Glen Dean in his definitive publication (1917). Named by Brokaw (1916) for Sloans Valley, Pulaski County, southeastern Kentucky.

Snyder sands

Drillers term for the Cypress (Snyder shallow) and Bethel (Snyder deep) Sandstones in Indiana.

Solsberry Formation

Abandoned, poorly defined term used only once for all or most of the Chesterian of Indiana. Named by Greene (1911) for the town of Solsberry in secs. 32 and 33, T. 8 N., R. 3 W., Solsberry Quad., Greene Co., Ind. (fig. 3, loc. 81).

SPAR MOUNTAIN SANDSTONE MEMBER

Sandstone and related sandy, silty, or shaly sediments of Genevievean age, overlying the massive pure carbonates of the Fredonia Limestone Member, as restricted in this report, and underlying those of the Karnak Limestone Member. All three are assigned to the Ste. Genevieve Formation. This unit has commonly been misidentified as Rosiclare throughout the subsurface of the Illinois Basin and in nearly all outcrop areas save those of the fluorspar district. However, it lies 30 to 70 feet beneath the Rosiclare Sandstone Member, which is the most important unit in the Aux Vases Sandstone. Named by Tippie (1945) for exposure of sandy limestone on the Spar Mountain escarpment 55 to 60 feet beneath the Aux Vases (Rosiclare) about 400 feet southwest of the site of the Benzon mill or the present Benzon cut of the Minerva Oil Company, SE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 3, T. 12 S., R. 9 E., Saline Mines Quad., Hardin Co., Ill. (fig. 3, loc. 39).

Sparta sand

Drillers term for the Cypress Sandstone in Randolph County, Illinois.

Stein sand

Drillers term for the Cypress Sandstone in Marion and Clinton Counties, Illinois.

Stenosisma—see “*Camarophoria*”

Stephensport Group

Group comprising the Beech Creek, Big Clifty, Haney (“Golconda”), Hardinsburg, and Glen Dean Formations in Indiana. It was first used with this precise meaning by Gray et al. (1960), who modified a suggestion by Cumings (1922) that excluded the Beech Creek and a usage by Foerste (1910) that included only the Glen Dean, Hardinsburg, and Haney. Named for the town of Stephensport, N $\frac{1}{2}$ 2-Q-36, Rome Quad., Breckinridge Co., Ky. (fig. 3, loc. 63).

Stevens sand

Drillers term for Tar Springs Sandstone in the Owensboro district, Kentucky.

Streptognathodus unicornis Assemblage Zone

A conodont zone proposed by Collinson, Scott, and Rexroad (1962); equivalent to the Grove Church Formation.

Subcarboniferous

Term used in many early reports for the Mississippian System or (in the form subcarboniferous limestone) for the Mammoth Cave Limestone Megagroup.

Sulcatopinna missouriensis

This large razor clam is found rather commonly in upright living position in fine-grained limestone beds in the Menard Formation, where it has been used as an index. It occurs sparingly in similar limestone as low as the Fraileys and as high as the Kinkaid. It was used by S. Weller (1926) and by others to designate a range zone at a time that its range was believed to extend from the Vienna to the Kinkaid.

Swan Creek Sandstone

Abandoned, preoccupied name for a sandstone bed locally 20 to 40 feet thick forming the lower part of the Joppa Member of the Aux Vases Sandstone. Named by Ulrich (1922) for exposures in two gullies in the east side of Swan Creek, north of Anna and opposite the east entrance to the State Hospital, NW $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 17, T. 12 S., R. 1 W., Dongola Quad., Union Co., Ill. (fig. 3, loc. 22).

Talarocrinus Range Zone

A zone encompassing the ranges of all species of *Talarocrinus* except *T. simplex*. It is equivalent to beds from the Shetlerville through the Ridenhower, that is, to all fossiliferous Gasperian rocks except the Beech Creek Limestone. *T. simplex* of the Salem is a small, smooth form with hemispherical base, probably not closely related to the Gasperian species, which have inflated plates and depressed sutures and can for practical purposes be identified as a group by isolated half-disclike basal plates.

TAR SPRINGS SANDSTONE or SHALE

Sandstone and shale with occasional beds

of coal and sandy limestone of early Elviran age overlying the Glen Dean Limestone and underlying the Vienna Limestone. The Vienna is overlapped toward the north edge of the basin by very fine-grained, low resistivity shales of the Waltersburg. Named by Owen (1856, 1857) for Tar Springs, NW $\frac{1}{4}$ 13-P-35, Cloverport Quad., Breckinridge Co., Ky. (fig. 3, loc. 57).

Tennessean System

Time-stratigraphic unit comprising the Warsaw Shale and all younger Mississippian Formations—the Meramecan plus Chesterian. It is not currently used although it is the precise equivalent of the “Upper Mississippian Series” in current use by the U. S. Geological Survey. Named by Ulrich (1905, 1911) for the state of Tennessee.

Tip Top Sandstone or Sand

Synonym used in Kentucky for the Ohio River Formation, a relatively unconsolidated deposit assigned by some to the Tertiary, but correlated by Ray et al. (1947) and by me with the Bethel Sandstone. Named by Sutton (1931) for an abandoned pit just south of where the Illinois Central Railroad crosses the Meade-Hardin county line, half a mile northwest of Tip Top, 3000 feet from the south line and 4200 feet from the west line of 25-R-43, Fort Knox Quad., Meade Co., Ky.

Tracey sand

Drillers term applied primarily to Bethel Sandstone in Lawrence County, Illinois, but also including some Aux Vases, Yankeetown, and possibly Sample.

Tracy sand

Drillers term, possibly only a variant of Tracey, applied apparently to Aux Vases Sandstone in Indiana.

Tribune Limestone

Abandoned term meant to apply to the Beaver Bend, Reelsville, and perhaps Beech Creek Limestones. However, the type section is of the much younger Menard Limestone. Named by Ulrich (1904, 1905) for exposures a third of a mile west of

Tribune, in the NW $\frac{1}{4}$ 25-K-19, Shady Grove Quad., Crittenden Co., Ky. (fig. 3, loc. 42).

TYGETT SANDSTONE MEMBER or SHALE MEMBER

Name proposed in this report for the middle clastic member of the Clore Formation of Elviran age, overlain by the Cora Member and underlain by the Ford Station Member, both relatively high-carbonate units. The type section (fig. 11) is on the south bank of Bradshaw Creek, 0.4 mile southeast of Water Valley school and 1.5 miles north of Tygett school, where 26 feet of sandstone and shale overlies 5 feet of shale with limestone nodules that forms the upper part of the Cora Member, and underlies a nearly complete exposure of 36 feet of shale and limestone of the Ford Station Member, NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 24, T. 11 S., R. 1 W., Carbondale Quad., Union Co., Ill. (fig. 3, loc. 23).

Upper Mississippian Series

In current U. S. Geological Survey practice, Meramecan plus Chesterian—that is, all Mississippian rocks younger than the base of the Warsaw Shale. It is equivalent to Chesterian in most geologic literature.

VALMEYERAN SERIES

The middle of three series in the Mississippian, overlying the Kinderhookian and underlying the Chesterian Series. It comprises all rocks deposited contemporaneously with the section from the base of the Fern Glen Formation to the top of the Levias Member of the Renault Formation. It is equivalent to the Meramecan plus Osagian of many authors. The ending “an” is preferred because of uncertainty as to the pronunciation of Valmeyerian. Named by J. M. Weller and Sutton *in* Moore (1933) for excellent outcrops in Dennis Hollow near the town of Valmeyer, secs. 3 and 10, T. 3 S., R. 11 W., Kimmswick Quad., Monroe Co., Ill. (fig. 3, loc. 1).

VIENNA LIMESTONE

Limestone with only minor amounts of calcareous shale overlying clastic rocks of

the Tar Springs Formation and underlying those of the Waltersburg Formation. Although much shale was originally placed in the Vienna, in recent usage the formation has been restricted to beds of brown, cherty, or siliceous limestone. Named by S. Weller (1920a) for exposures in and around Vienna, the particular outcrop generally cited being 14 feet of limestone in a small abandoned roadside quarry west of Vienna on the south side of Illinois Highway 146 0.9 mile west of its junction with U. S. 45, NE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5, T. 13 S., R. 3 E., Vienna Quad., Johnson Co., Ill. (fig. 3, loc. 31).

Vierling sand

Drillers term, probably for Aux Vases Sandstone in Indiana.

WALCHE LIMESTONE MEMBER

Name formally proposed in this report for the lowest and thinnest of the three main limestone members of the Menard Formation of Elviran age, commonly called the "little Menard." It overlies clastic rocks of the Waltersburg Formation and is separated from the middle or Scottsburg Limestone Member of the Menard by 3 to 30 feet of shale. The unit thins northward from the outcrop along the southern margin of the basin and is absent north of an irregular boundary near the base line in Illinois that swings southeastward across Indiana to the central part of Meade County, Kentucky. The type exposure (fig. 8) is 14 $\frac{1}{2}$ feet of limestone overlying 42 feet of Waltersburg Shale and is separated from the Scottsburg by 14 feet of shale. Named for the exposure in Walche's cut on the Illinois Central Railroad in the southwestern corner of 19-H-21, 6400 feet from the south line and 8600 feet from the east line of H-21, Princeton East Quad., Caldwell Co., Ky. (fig. 3, loc. 49).

WALTERSBURG FORMATION, SHALE, or SANDSTONE

Clastic rocks of Elviran age overlying the Vienna Limestone and underlying lime-

stone of the Menard Formation. The contact with the Menard steps up 5 to 30 feet at the northern limit of the Walche Limestone Member of the Menard, from the base of that member to the base of the Scottsburg Member. Named by S. Weller (1920a) for outcrops near Waltersburg, which is at the southeast corner of sec. 17, T. 13 S., R. 6 E., Brownfield Quad., Pope Co., Ill. (fig. 3, loc. 33).

Weiler sand

Drillers term for Cypress Sandstone used widely in Illinois and sparingly in Indiana and Kentucky.

WEST BADEN GROUP or SANDSTONE GROUP

Name used for the Bethel, Ridenhower, and Cypress Formations of Gasperian age, particularly in areas where the carbonate portions of the Ridenhower are so reduced that separation of the formations is impractical. It was introduced in this sense by Gray et al. (1960), who by excluding the Paoli Limestone revised a dormant usage suggested by Cumings (1922). Named for West Baden in sec. 34, T. 2 N., R. 2 W., French Lick Quad., Orange Co., Ind. (fig. 3, loc. 72).

Wickcliff Sandstone

Abandoned synonym for Waltersburg Sandstone. Named by Malott (1925) for exposures of sandstone about 30 feet above massive beds of Tar Springs Sandstone where the Vienna interval is represented only by shale, near Wickcliff, SW $\frac{1}{4}$ sec. 4, T. 2 S., R. 2 W., Birdseye Quad., Crawford Co., Ind. (fig. 3, loc. 70).

Willis sand

Drillers term for Cypress Sandstone in Indiana.

YANKEETOWN SANDSTONE, SHALE, or CHERT

Clastic rocks of Gasperian age overlying carbonate-bearing beds of the Renault Formation and underlying those of the Downeys Bluff Formation. In southwestern

Illinois and southeastern Missouri, white-weathering beds of fine sandstone cemented by chert are very characteristic. In the subsurface of western Illinois, the Yankeetown is represented by the Benoist oil sand. In much of Indiana and Kentucky the Yankeetown is represented only by shaly beds at or somewhat above the middle of the Paoli Limestone; these beds disappear near the southeastern corner of the basin and the position of the Yankeetown within the Paoli is uncertain. Named by S. Weller

(1913) for cherty sandstone float near Yankeetown school, which was located on the west side of the Ames-Waterloo Road a few hundred feet south of Prairie Branch Creek and a quarter of a mile north of the southeast corner of sec. 26, T. 4 S., R. 9 W., Renault Quad., Monroe Co., Ill. (fig. 3, loc. 4).

Zimmerman sand

Drillers term for Big Clifty Sandstone in Indiana.

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91 p., 1 plate, 23 figs., glossary, 1963

RIRIAN AND GENEVIEWIAN ROCK COLUMNS

DAVID H. SWANN
AND
ELWOOD ATHERTON
1962

This geological cross-section illustrates the subsurface structure of the western end of the study area. The profile is characterized by several distinct geological units and features:

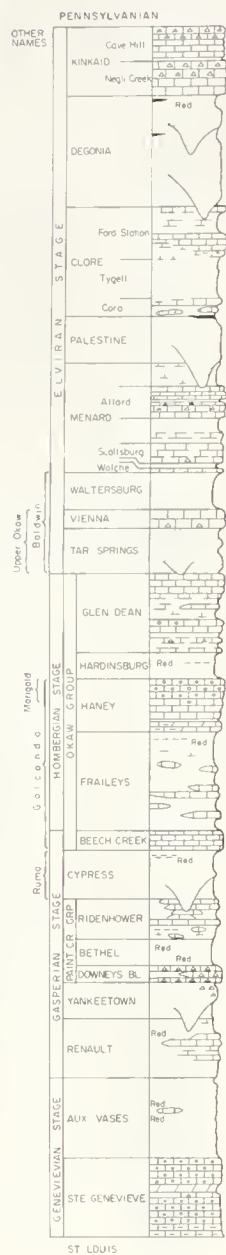
- Top Layer:** A thin, dotted layer representing a specific geological unit.
- Le:** A layer labeled "le" (likely limestone) shown as a brick pattern with two small triangles indicating specific features or faults.
- Red:** A layer labeled "Red" (likely red sandstone or shale) shown as a solid light-colored area.
- III:** A layer labeled "III" (likely a specific geological unit) shown as a brick pattern with two small triangles.
- Reek:** A layer labeled "Reek" (likely a specific geological unit) shown as a brick pattern with one small triangle.
- Red:** Another layer labeled "Red" (likely red sandstone or shale) shown as a solid light-colored area.
- Bottom Layer:** A thick, dotted layer representing a specific geological unit.
- ation:** A layer labeled "ation" (likely a specific geological unit) shown as a brick pattern with two small triangles.

The cross-section shows the complex interplay of these geological units, with the "Red" layers and the "le" and "III" layers being prominent features. The "Reek" layer is also a significant component of the subsurface structure.

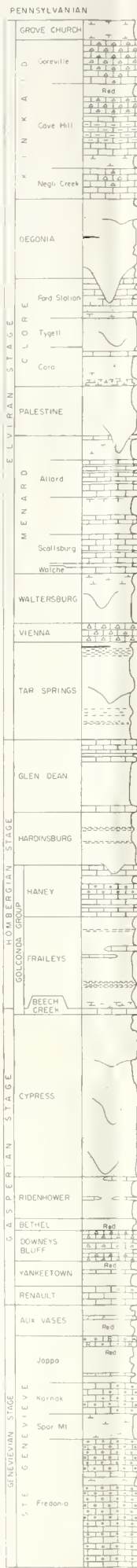
ILLINOIS
EQUIVALENTS

K. Negli Cr.		LEITCHFIELD	KINKAID	
DEGONIA			DEGONIA	
CLORE	Ford Sta.		CLORE	
	Tygett			
	Cora			
PALESTINE			PALESTINE	
MENARD			MENARD	
	Allard			
	Scottsburg			
WALTERS-		WALTERSBURG		

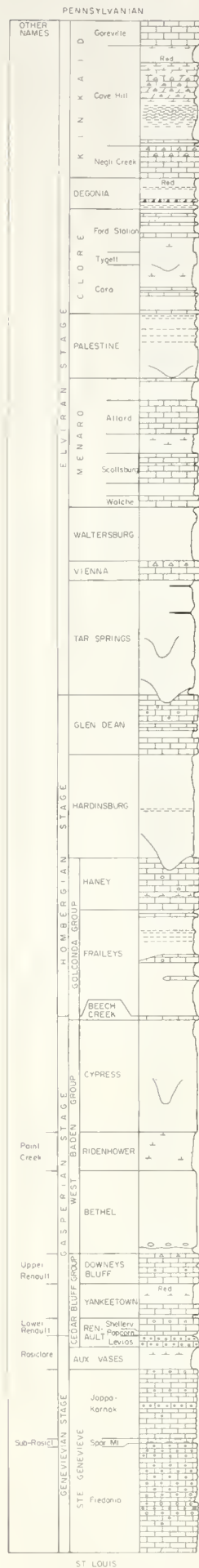
A - CHESTER DISTRICT



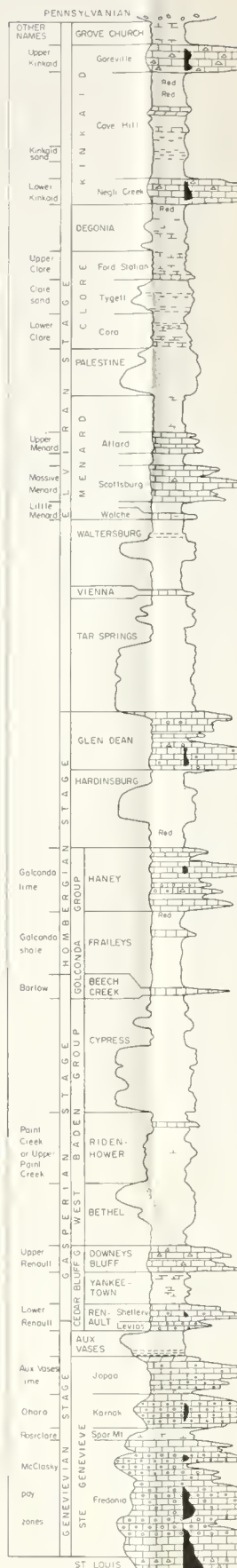
B - ANNA DISTRICT



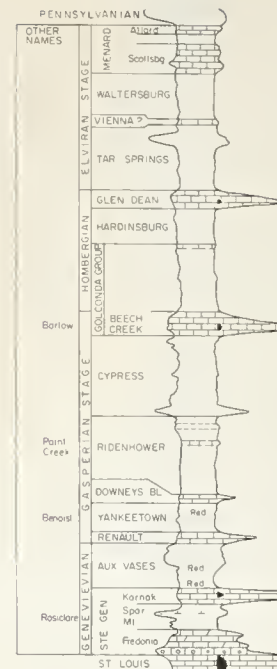
C - FLUORSPAR DISTRICT



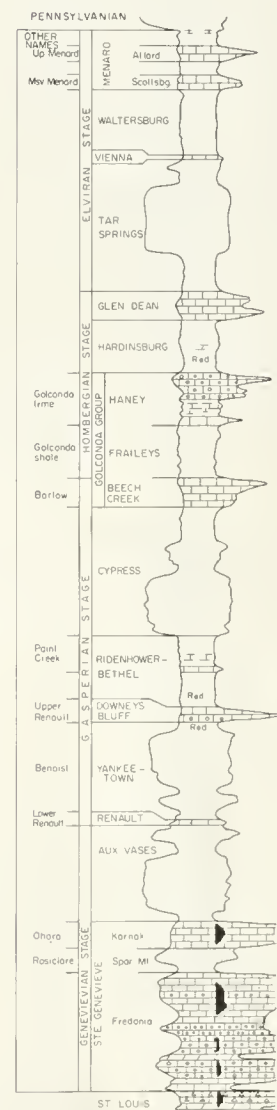
D - WHITE COUNTY



E - COLES COUNTY



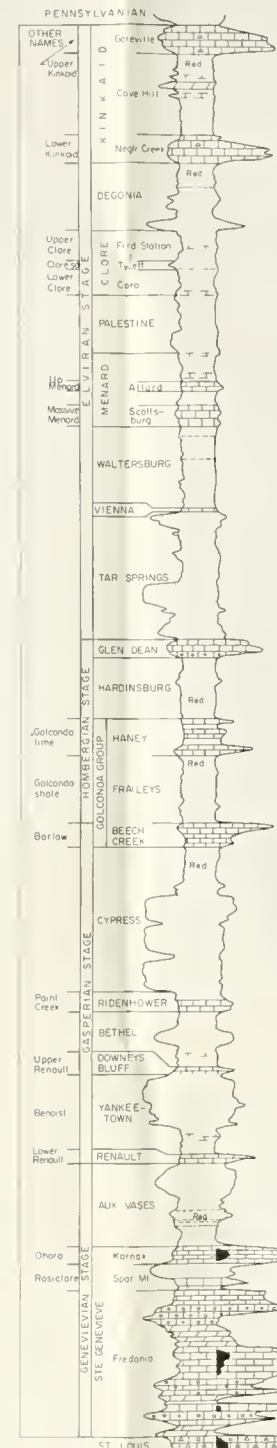
F - WASHINGTON COUNTY



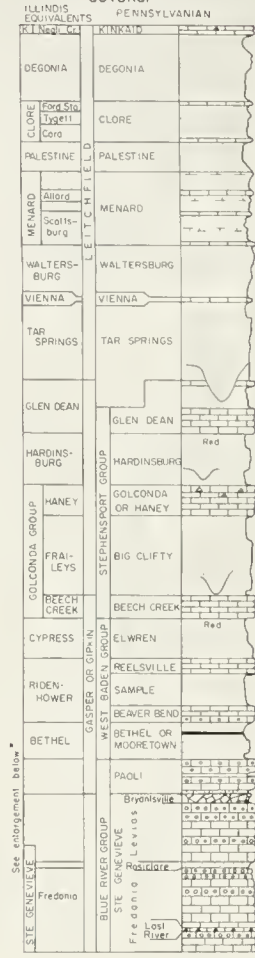
CHESTERIAN AND GENEVIEVIAN
ROCK COLUMNS

DAVID H. SWANN
AND
ELWOOD ATHERTON
1962

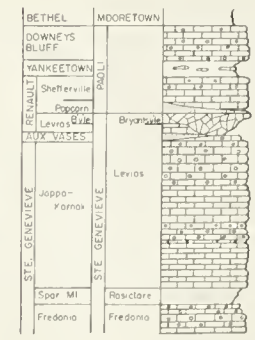
G - EFFINGHAM COUNTY



INDIANA-KENTUCKY
OUTCROP



* ENLARGEMENT



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LOCATION OF COLUMNS



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